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SIZE AND FORM OF THE FOOT IN MEN

by GUNNAR DAHLBERG and ELVIR LANDER

Earlier literature and material.

In anthropologic literature comparatively little is said about the build of the foot. Certainly the mean length, breadth etc. of the foot in various races are given, but to our knowledge the variability of the foot has not been studied as yet. This is surprising. Not so much, perhaps, from an anthropologic point of view but more so from a practical view-point. In shoe manufacturing, for instance, detailed information on how much the foot varies would make it possible to produce shoes that better fit the feet for which they are intended. However, no investigation of this kind has been published and at any rate in Sweden shoe manufacturing is based on rather approximate information and not on more exact scientific studies of foot structure taken from representative material.

The initiative to the present investigation was taken by the military authorities and shoe manufacturers in Sweden. Their object was to make available the information required to facilitate a rationalisation of the Swedish shoe industry so that military needs could be satisfied. Consequently the present report is based on measurements from the conscripts called up in 1945. Hereby a selection of sorts is made as those unfit for military service do not enter into our material. Excluded individuals, however, as a rule suffered from other disorders than foot diseases so therefore their absence makes little difference. The small percentage having foot diseases or deformed feet would also seem to be of little importance as normal measurements are what we wish to find.

Furthermore we have rejected a small number of persons with minor, real or suspected, foot defects, 10 persons of foreign extraction and 43 persons on account of incomplete or faulty registration. The remaining material comprises 8232 conscripts most of whom are young men. The age distribution is given in table 1.

Table 1

Distribution of the cases according to age.

Age in years	Number	%
17—20	471	5.7
21	6625	80.5
22—24	531	6.4
25—34	260	3.2
35—47	345	4.2
Total	8232	100.0

As we see the statistically used material includes 5.7 % individuals in the age group 17–20 years. Expressed as a percentage of the number of conscripts who are at most 21 this figure rises to 6.6. Exactly the same average figure was obtained at medical examinations of conscripts through the years 1943–45. The proportion of conscripts below prescribed age thus corresponds to the figure for the entire army.

The question is whether or not individuals below conscription age should be sorted out. In answering this question it should be kept in mind that anyone who receives permission to do his term of military service in advance has a particularly good physical constitution and is well developed for his age. They constitute a selection of physically better developed people than the average. If these are sorted out, then, the remainder will evidently be less representative as they, in a manner of speaking, are a selection of the less well developed. From this point of view it has been considered correct not to exclude them. The number of individuals in the higher age groups is not very large. (See table 1.) The majority or 80.5 % are 21. Only 13.8 % are over 21.

Looking at table 2 we find a slight tendency to lower stature with increasing age. This might have been expected as the stature in Sweden increases generation by generation. Older age groups should therefore be shorter than younger age groups. The difference amounts to approximately 1 cm per decade (cf. *Hultkrantz*, 1927). But we do have a negligible increase in height after the age of 21 which counteracts this tendency. At any rate it probably is not strong enough to make any difference, and we have mentioned

Table 2

Distribution of the cases according to stature within the different age groups.

Stature, cm.	Age in years					
	17—20	21	22—24	25—34	35—47	Total
153—157	—	10	—	1	1	12
158—162	3	101	6	8	6	124
163—167	13	470	33	16	36	568
168—172	59	1573	100	62	95	1889
173—177	120	1956	151	76	110	2413
178—182	149	1724	142	62	69	2146
183—187	93	636	72	30	21	852
188—192	29	125	20	3	5	182
193—197	4	24	7	—	—	35
198—202	1	6	—	2	2	11
Total	471	6625	531	260	345	8232
Mean stature	178.6	175.4	176.7	175.2	174.0	175.6

Table 3

Distribution of the cases according to weight in the different age groups.

Weight, kg.	Age in years					
	17—20	21	22—24	25—34	35—47	Total
49—52	1	20	2	2	—	25
53—57	13	187	15	5	10	230
58—62	62	880	70	26	25	1063
63—67	110	1768	124	50	74	2126
68—72	138	1952	160	80	80	2410
73—77	92	1135	98	58	65	1448
78—82	41	515	42	26	55	679
83—87	11	139	16	10	18	194
88—92	3	24	2	2	8	39
93—97	—	1	2	—	5	8
98—102	—	4	—	1	3	8
103—107	—	—	—	—	2	2
Total	471	6625	531	260	345	8232
Mean weight	69.4	68.8	69.6	70.6	72.4	69.1

it more for the sake of completeness than anything else. The mean stature for 20 year old conscripts was 174.7 and 174.9 cm in 1945 and 1946 respectively. These figures are very close to those obtained by us and this implies that our material is sufficiently representative.

Table 3 gives the figures for the body weight at different ages. Again we find a greater weight in the 17–20 year olds than in the 21 year olds which probably is due to the above mentioned selective element. We also find that body weight like stature increases from 21 years to the age group 22–24 years, which probably is due to a slight growth after 21. The increase registered in subsequent age groups is probably, however, due to a general tendency to increase in weight, partly on account of ageconditioned corpulence. The figures are interesting in as much as they show that the load on the feet may be expected to become slightly greater with increasing age.

By way of summing up we can confidently say that the material is very representative.

Measuring technique.

A measuring apparatus constructed by Mr. *Nils Haraldson* of Örebro, Sweden, was used for these foot measurements. In principle it consists of various devices for measuring the distance between different points and the angles between different directions. The measurements taken were those required by the shoe industry and not always the most interesting measurements from a scientific point of view. The most important omission is that "height" measurements of the foot are lacking. The measurements taken are shown in fig. 1. Naturally the 18 measurements are of different value. To get some idea of the reliability of our measurements we have had double measurements taken on 50 conscripts. This second batch of measurements was taken by the same person who had taken the first lot. From the figures obtained has been calculated the standard error of measurement (see table 4) according to the formula

$$\sigma_m = \sqrt{\frac{\Sigma d^2}{2n}}$$

where σ_m is the error of measurement and d = the difference between the two figures obtained and n = the number of double measurements. The table also gives the error of measurement expressed as a percentage of the respective mean (a kind of variation coefficient).

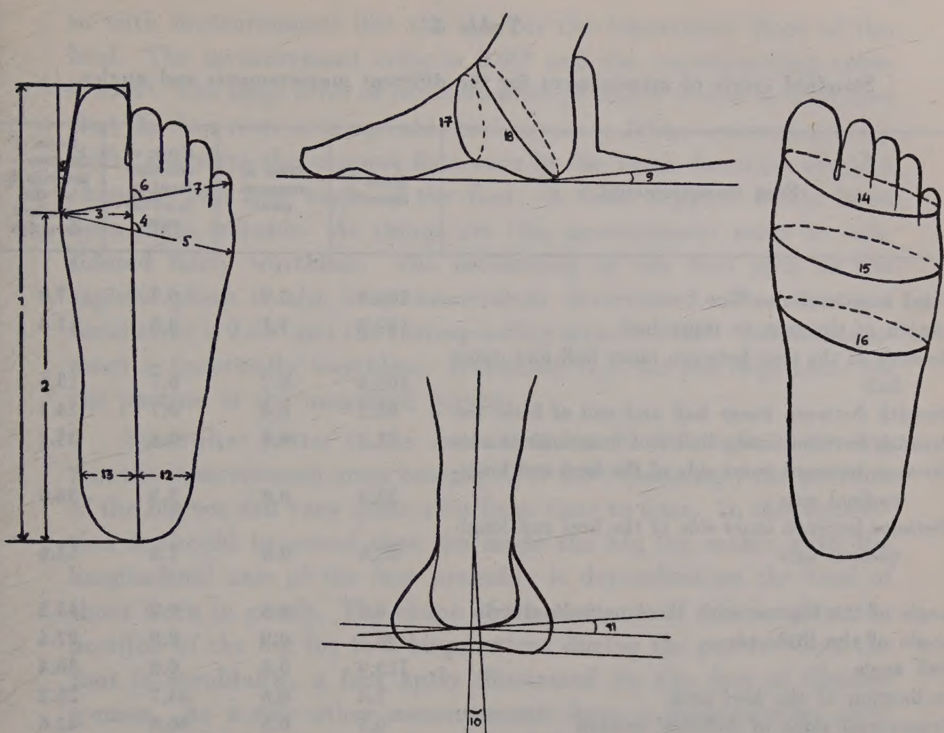

Fig. 1. The different foot measurements. 1. Total length of the foot. 2. Length of the foot to inner ball. 3. Breadth between inner ball and longitudinal axis. 4. Ball angle. 5. Breadth of the foot between inner ball and outer ball ("foot breadth"). 6. Angle of the little toe. 7. Breadth between inner ball and end of little toe. 8. Angle of the big toe with the longitudinal axis. 9. Inclination of the heel arch. 10. Transversal slope of Achilles' tendon. 11. Transversal slope of the heel. 12. Distance between outer side of the heel and longitudinal axis. 13. Distance between inner side of the heel and longitudinal axis. 14. Width of the foot around the toes. 15. Width of the foot around the balls ("ball width"). 16. Middle tarsal width. 17. Tarsal width. 18. Heel – tarsal width.

Clearly the value of such percentages is doubtful as they depend not only on the magnitude of the error of measurement but also on the mean, the result being that the error expressed as a percentage becomes infinitely large when the mean is zero. This may be the case with measurements which are either positive or negative in value. Also, it is clear that the error of measurement will be comparatively large expressed as a percentage of a mean which is nearly

Table 4

Standard errors of measurement for the different measurements and angles.

Foot measurements	Mean figure	Error of measurement	Error of measurement in % of the mean	Error of measurement in % of the standard deviation
Total length of the foot	266.3	0.9	0.3	7.0
Length of the foot to inner ball	199.8	1.1	0.5	11.4
Breadth of the foot between inner ball and outer ball	105.6	0.7	0.7	13.6
Breadth between inner ball and end of little toe	98.2	0.6	0.7	14.1
Breadth between inner ball and longitudinal axis	35.3	0.9	2.4	33.1
Distance between outer side of the heel and longitudinal axis	33.8	0.8	2.3	38.0
Distance between inner side of the heel and longitudinal axis	33.6	0.6	1.8	32.6
Angle of the big toe with the longitudinal axis	8.6	0.8	9.2	15.5
Angle of the little toe	96.2	0.9	0.9	27.4
Ball angle	113.9	0.8	0.8	30.4
Inclination of the heel arch	1.4	0.6	44.7	25.2
Transversal slope of Achilles' tendon	0.5	0.5	90.6	43.6
Transversal slope of the heel	–0.4	0.6	162.5	32.5
Width around the toes	237.9	1.5	0.6	12.9
Width of the foot around the balls	256.1	1.4	0.5	11.1
Middle tarsal width	243.0	1.5	0.6	12.6
Tarsal width	259.6	1.5	0.6	11.4
Heel — tarsal width	349.2	1.9	0.6	13.0

zero. When as in the present report we are dealing with angular measurements the use of percentage errors may be considered rather unsuitable. A better expression of the importance of the error of measurement may be gained by also giving it as a percentage of the standard deviation of the measurement in question. Then we get an idea of the part played by the error of measurement for the actual variation found in the respective measurements. The error in measurements of distances is of course above all due to variations in pressure on the soft parts of the foot and the somewhat vague location of the end points of the measured distance. The table shows that as a rule the angular values are relatively uncertain. This is especially

so with measurements like the one for the transversal slope of the heel. The measurement error is 0.65^0 and the corresponding mean is 0.40^0. The large error of measurement probably is due to that fact that the foot rests on a movable heel support. If the centre of gravity shifts sideways the support lists over in the same direction thereby changing the heel angle of the foot. A fixed support would have been more suitable. As things are this measurement must be considered fairly worthless. The inclination of the heel arch in the sagittal plane is also very uncertainly determined. The measurement error is 0.63^0 and the corresponding mean is 1.41^0. The measurement is practically worthless. Evidently it is far too dependent on the posture of the measured person.

Somewhat better is the determination of the angle of the big toe, the measurement error being 9 % or 0.8^0. Seemingly the position of the big toe can vary quite a lot from time to time. In this connection it should be noted that the angle the big toe makes with the longitudinal axis of the foot probably is dependent on the kind of shoes worn in youth. The shape of the shoe can of course affect the position of the big toe to a large extent during the period when the foot is mouldable, a fact aptly illustrated by the feet of Chinese women. As a rule other measurements have a measurement error of less than 1 %. Only the breadth of the heel perpendicular to the longitudinal axis manifests a comparatively large measurement error. Apart from the above mentioned angular measurements the measurements for the individual persons would seem to be satisfactorily exact. Summing up we can say that except for some of the angular measurements the technique adopted is very satisfactory.

The Variation in the Foot-build.

In the first place it is now of interest to find means for the various measurements and to get an idea of the dispersion around these means. Before giving these figures we shall, however, study the distribution of the foot measurements, i. e. to what extent the distribution agrees with a normal curve. In so doing we first present a table over calculated and observed distribution. The calculated distribution is obtained by the use of mean and standard deviation and is accordingly what could be expected if the distribution were absolutely normal (see table 5 and fig. 2). A glance at the table and the figure will show that the agreement is very good.

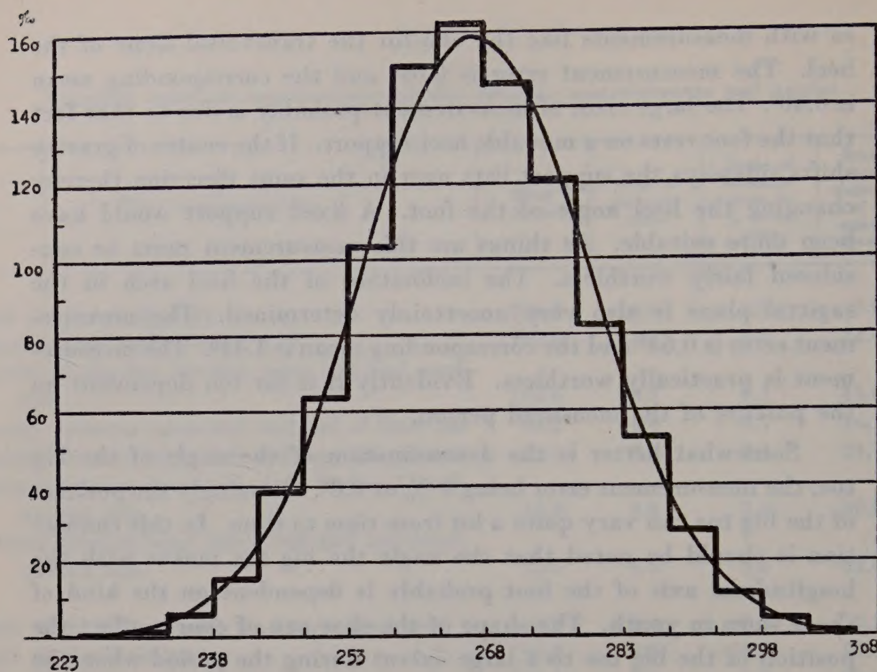

Fig. 2. **Length of the foot in 8232 men, distributed on classes of 5 mm (thick line) and the corresponding normal curve (thin line).**

In table 6 we then give the means and standard deviation for the various measurements. We have furthermore calculated excess and skewness. The latter characteristics are insignificant. We may therefore take it as a fact that the foot measurements studied are distributed according to a normal curve. The transversal slope of the heel is an exception. It has a significant excess. An explanation of this may be that the investigator had a definite tendency to put "0" for small deviations from the vertical plane, but as we have already emphasised this measure is of little interest as it suffers from a considerable error of measurement.

The table also contains information concerning two calculated indexes, viz. the breadth of the foot as a percentage of the length and the breadth of the foot as a percentage of the ball width. The first of these indexes is a rough measure of the shape of the foot in the horizontal plane. The latter index is as imperfect a measure of the height of the foot. The first index (breadth as a percentage of length) manifests no skewness or excess. The latter index (breadth

Table 5

Calculated and observed distribution of the length of the foot.

Foot length, mm.	Observed distribution		Distribution calculated accord. to a normal curve	
	Number	‰	Number	‰
208—212	1	0.1	—	—
213—217	1	0.1	—	—
218—222	—	—	1	0.2
223—227	3	0.4	6	0.7
228—232	14	1.7	19	2.3
233—237	53	6.4	57	6.9
238—242	132	16.0	142	17.3
243—247	319	38.8	305	37.0
248—252	530	64.4	557	67.6
253—257	857	104.1	867	105.3
258—262	1248	151.6	1151	139.8
263—267	1340	162.9	1300	157.9
268—272	1211	147.1	1259	152.9
273—277	999	121.4	1036	125.9
278—282	684	83.1	727	88.3
283—287	441	53.6	435	52.9
288—292	235	28.5	222	27.0
293—297	100	12.1	97	11.7
298—302	43	5.2	36	4.4
303—307	15	1.8	11	1.4
308—312	3	0.4	3	0.4
313—317	2	0.2	1	0.1
318—322	—	—	—	—
323—327	1	0.1	—	—
Total	8232	1000.0	8232	1000.0

as a percentage of ball width) on the other hand shows definite skewness and likewise definite excess. Even if this is the case the magnitude of these parameters does not point to any important deviations from a normal distribution. Consequently we raise no objections to the use of the standard deviation as a measure of the variability. In additional support of this we give in table 7 the percentage of cases falling outside 3 σ reckoned from the mean. This number should be 0.27 %. On the whole the observed figure is slightly higher but the deviation should be of no importance.

Table 6

Mean (M), standard error of the mean (ε), standard deviation (σ), skewness and excess of the differ measurements and angles.

Measurements of the foot	Mean	Standard deviation	Skewness	Excess
	$M \pm \varepsilon$ (M)	$\sigma \pm \varepsilon$ (σ)	$S \pm \varepsilon$ (S)	$E \pm \varepsilon$ (E)
Total length of the foot	266.4±0.14	12.5±0.10	+0.05±0.01	+0.01±0.
Length of the foot to inner ball	199.4±0.10	9.5±0.07	+0.04±0.01	+0.01±0.
Length of the foot from inner ball to end	67.0±0.05	4.8±0.04	—	—
Breadth of the foot between inner ball and outer ball	106.6±0.06	5.3±0.04	—0.07±0.01	—0.002±0.
Breadth between inner ball and end of little toe	99.4±0.05	4.6±0.04	+0.10±0.01	+0.02±0.
Breadth between inner ball and longitudinal axis	35.5±0.03	2.6±0.02	+0.09±0.01	+0.01±0.
Distance between outer side of the heel and longitudinal axis	34.7±0.02	2.0±0.02	+0.04±0.01	—0.02±0.
Distance between inner side of the heel and longitudinal axis	33.9±0.02	1.9±0.02	+0.05±0.01	—0.002±0.
Breadth of the heel	66.7±0.18	2.5±0.12	—	—
Angle of the big toe with the longitudinal axis	—5.8±0.06	5.1±0.04	+0.06±0.01	+0.03±0.
Angle of the little toe	94.1±0.03	3.1±0.02	+0.09±0.01	+0.02±0.
Ball angle	112.1±0.03	2.5±0.02	+0.19±0.01	+0.15±0.
Inclination of the heel arch	—2.1±0.03	2.5±0.02	+0.01±0.01	+0.01±0.
Transversal slope of Achilles' tendon	0.9±0.01	1.1±0.01	+0.06±0.01	—0.02±0.
Transversal slope of the heel	—0.4±0.02	2.0±0.02	+0.15±0.01	+0.05±0.
Width around the toes	237.7±0.13	11.4±0.09	+0.05±0.01	+0.02±0.0
Width of the foot around the balls	256.2±0.14	12.4±0.10	+0.04±0.01	+0.01±0.0
Middle tarsal width	245.2±0.13	11.6±0.09	+0.05±0.01	—0.003±0.0
Tarsal width	261.2±0.15	13.6±0.11	+0.13±0.01	+0.03±0.0
Heel — tarsal width	340.1±0.16	15.0±0.12	+0.07±0.01	+0.03±0.0
Breadth of the foot in % of total length	40.1±0.02	1.8±0.01	+0.14±0.01	+0.08±0.0
Breadth of the foot in % of the width around the balls	41.7±0.01	1.0±0.01	+0.36±0.01	+0.45+0.0

In table 6 we gave means and standard deviations for various foot measurements expressed in mm and degrees. In table 8 we finally give variation limits for the different measurements calculated by means of the standard deviations. From this table it appears

Table 7

Number and per cent men with foot measurements deviating more than 3 σ from the mean.

Measurements of the foot	Outside M$\pm$3 σ	
	Number	%
Total length of the foot	20	0.24
Length of the foot to inner ball	88	1.07
Breadth of the foot between inner ball and outer ball	27	0.32
Breadth between inner ball and end of little toe	93	1.12
Breadth between inner ball and longitudinal axis	34	0.42
Distance between outer side of the heel and longitudinal axis	56	0.68
Distance between inner side of the heel and longitudinal axis	71	0.86
Angle of the big toe with the longitudinal axis	73	0.89
Angle of the little toe	36	0.44
Ball angle	49	0.59
Inclination of the heel arch	47	0.57
Transversal slope of Achilles' tendon	45	0.54
Transversal slope of the heel	111	1.34
Width around the toes	35	0.43
Width of the foot around the balls	24	0.30
Middle tarsal width	29	0.34
Tarsal width	38	0.45
Heel — tarsal width	43	0.52
Breadth of the foot in % of total length	49	0.59
Breadth of the foot in % of the width around the balls	94	1.14
Mean		0.64
Expected figure		0.27

that, for instance, the length of the foot may vary from 229 to 304 mm. and that at the same time the breadth may vary from 91 to 123 mm. The broadest foot is in other words as broad as a little more than half the length of the shortest foot.

By means of information given in the tables as to means and standard deviations for different measurements it is now easy to calculate the number of individuals to be expected in different measurement classes within the limits of normal variation. There-

Table 8

Range of variation for different measurements, calculated on the basis of 6 σ.

Measurements of the foot	Range of variation (=6 σ)	$(M-3\sigma)-(M+3\sigma)$
Total length of the foot	75.0	228.9 — 303.9
Length of the foot to inner ball	57.0	170.9 — 227.9
Breadth of the foot between inner ball and outer ball	31.8	90.7 — 122.5
Breadth between inner ball and end of little toe	27.6	85.6 — 113.2
Breadth between inner ball and longitudinal axis	15.6	27.7 — 43.3
Distance between outer side of the heel and longitudinal axis	12.0	28.7 — 40.7
Distance between inner side of the heel and longitudinal axis	11.4	28.2 — 39.6
Angle of the big toe with the longitudinal axis	30.6	—21.1 — +9.5
Angle of the little toe	18.6	84.8 — 103.4
Ball angle	15.0	104.6 — 119.6
Inclination of the heel arch	15.0	—9.6 — +5.4
Transversal slope of Achilles' tendon	6.6	—2.4 — +4.2
Transversal slope of the heel	12.0	—6.4 — +5.6
Width around the toes	68.4	203.5 — 271.9
Width of the foot around the balls	74.4	219.0 — 293.4
Middle tarsal width	69.6	210.4 — 280.0
Tarsal width	81.6	220.4 — 302.0
Heel — tarsal width	90.0	295.1 — 385.1
Breadth of the foot in % of total length	10.8	34.7 — 45.5
Breadth of the foot in % of the width around the balls	6.0	38.7 — 44.7

fore, on account of the great practical importance of these measurements, we have at length in the foregoing discussed to which extent the distribution agrees with a normal curve.

The character of the foot from a regional point of view.

The isolates making up the Swedish population can be expected to manifest some genetic differences of small account. When Sweden originally was settled the country was very sparsely populated. We do not know whether the original population consisted of one

homogeneous race or of several different races. Whichever is the case repeated immigrations have taken place and they must surely have caused local differences. We may further suppose that in the scattered population where the isolates were very small random deviations developed partly by the loss of genes in the original populations and later through mutations. These differences which on the whole arise at random have been counteracted by a breaking down of the isolates as a result of the development of communications, the call from the cities, industrialisation etc.

In Sweden it is widely believed that the population has different characteristics in different parts of the country. Although it is not suggested that they belong to different races a popular contention is that they have their individual distinctions which has to do with the belief in different temperaments in different provinces. The home district is eulogised by stating that not only the countryside but also the people are different from their counterparts. The belief in local differences has, however, not received the expected support from the small number of scientific investigations that have been carried out. Here it is hardly possible to enter into the complications of this subject. With the above considerations in view we did, however, consider it worth while to investigate the character of the foot in different provinces. We shall, however, remain content by limiting the investigation to some large districts and to the most important foot measurements. As age differences conceivably could influence results we have used the 21 year olds only for this part of the investigation.

In the first place we thought it interesting to compare urban and rural districts. In so doing we put the four largest cities, Stockholm, Gothenburg, Malmö and Norrköping in one separate group, other cities in another group and all the rest in a third group. The material was grouped by birthplace. A person domiciled in Stockholm but born in the country has been put in a rural group. It has previously been proved that constitutional differences in different districts are insignificant. The population of Stockholm is most mixed and therefore has the greatest stature in Sweden. The increase in stature which has taken place during the last century is in the main probably due to a breaking down of this kind of isolates. (Cf. *Broman*, *Dahlberg* and *Lichtenstein*, 1942.)

Table 9 gives figures for the stature in these districts. As we have already seen the differences are insignificant. The four largest

Table 9

Stature, weight and Rohrer's index of 21-year-old men born in the four largest towns, in the other towns and in the country.

Place of birth	Number	Stature cm.	Weight kg.	Rohrer's index
The four largest towns	735	177.5±0.22	68.9±0.24	1.23
The other towns	1100	175.9±0.18	68.2±0.20	1.25
The country	4742	174.9±0.09	69.0±0.10	1.29
The whole country	6577	175.4±0.08	68.8±0.08	1.27

cities lead in this respect. Here the stature is 2.1 cm. greater than in the entire country. Other cities have a stature 0.5 cm. greater than the mean for the entire country. Consequently the rural population on an average is shorter than that of the entire country. The difference is 0.5 cm. An investigation carried out by the State Institute of Human Genetics and Race Biology in the years 1922–24 on conscripts yielded differences between the different districts and the entire country of +0.80 for the four largest cities, +0.04 for the other cities and —0.12 for the rural districts. In other words, the tendency was the same as now. That the figures were not exactly the same may partly be due to the dissimilarity in the distribution of individuals on the different districts and to sampling errors.

The number of cases used for this investigation into foot characteristics is, as we see, not as large as that used for the previous investigation of the State Institute of Human Genetics and Race Biology. The important thing is, however, that with this grouping the differences are very small. Figures of body weight are also given in this material but not in the material of the previous investigation. What is especially important from a general point of view is that the weight is greatest in conscripts from rural districts and lowest in the group "other cities". There is, however, no significant difference between the urban and the rural population as regards weight. But we have found that conscripts from large cities are somewhat taller than those from rural districts. If this fact is taken into consideration (for instance by calculating *Rohrer*'s index which is the weight in relation to the third power of the stature) we shall find that conscripts from large cities are most lean,

"other cities" comes next. Conscripts from rural districts are on the average slightly more corpulent. The differences are, however, not large and therefore of little practical value although they may be interesting from a scientific point of view. They prove that the increased stature in large cities cannot be due to better nutrition.

But the size of the foot is correlated to the stature. On an average very tall men have larger feet than short-statured men and by special computations to be described in the following we have determined the relationship between the stature on the one hand and the length and breadth, respectively, of the foot, on the other.

Table 10

Observed and calculated foot measurements for men born in the four largest towns, in the other towns and in the country.

Foot measurements	Place of birth			
	The four largest towns	The other towns	The country	All Sweden
Observed figures :				
Length of the foot	267.4±0.46	265.6±0.37	266.7±0.18	266.6±0.15
Breadth of the foot	105.7±0.19	106.1±0.16	107.1±0.08	106.8±0.07
Breadth in % of the length	39.6±0.06	40.0±0.05	40.2±0.03	40.1±0.02
Tarsal width	262.7±0.50	261.2±0.41	262.1±0.20	262.0±0.17
Heel — tarsal width	339.8±0.55	339.6±0.45	339.6±0.22	339.6±0.18
Figures calculated on the basis of stature :				
Length of the foot	268.6	266.7	265.5	—
Breadth of the foot	107.3	106.8	106.5	—
Breadth in % of the length	39.9	40.0	40.1	—

In table 10 we give both the foot length, calculated by means of the regression equation, and the observed foot length. We find that the observed foot length agrees fairly well with the calculated one. The regression equation used is calculated on the entire material, i. e. on all age groups. In such circumstances the agreement between observed and calculated values must be considered to be surprisingly good. Taking the four largest cities as an example the calculated foot length is 268.6. The actual one 267.4. Since the standard error is 0.46 mm. the difference is probably due to random variation.

The difference between calculated and actual length is only slightly more than 1 mm. Comparing actual and calculated foot breadths we also find insignificant differences. The only conclusion is that these insignificant differences in the length and breadth of the foot between the three regional groups in our investigation on the whole must be due to the difference in stature which in its turn is due to the more or less mixed population in these districts. The differences found in tarsal width and heel-tarsal width are small and not statistically significant. One method of finding a measure for the correlation between the length and breadth of the foot is to calculate the breadth as a percentage of the length. It appears that there are no differences worth mentioning in this percentage. But the "large cities" group do show a tendency to have slightly narrower feet, which may also be concluded from the fact that the feet are longest in this group while breadth is smallest. Then comes "other towns" and lastly rural districts. Here, however, the differences are insignificant and amount to only some tenths of one percent.

Having investigated the difference between urban and rural populations we still have to find eventual differences between various country districts. The material is too small to permit of grouping by counties or communities and it has been necessary to limit the investigation to larger units. Our grouping is the following:

1. *Northern Sweden*, comprising Västernorrland, Västerbotten and Norrbotten counties.

2. *Western Sweden*, comprising Göteborgs and Bohus, Älvsborg, Skaraborg, Värmland, Örebro, Västmanland, Kopparberg and Jämtland counties.

3. *Eastern Sweden*, comprising Stockholm, Uppsala, Södermanland, Östergötland, Jönköping, Kronoberg, Kalmar, Gotland and Gävleborg counties.

4. *Southern Sweden*, comprising Blekinge, Kristianstad, Malmöhus and Halland counties.

5. The four largest cities form a fifth group.

In table 11 are given stature and body weight for these five subdivisions. The difference in stature in them is unimportant. The four largest cities have as we have already seen the greatest stature

Table 11

Stature, weight and Rohrer's index for 21-year-old men born in four different parts of Sweden respectively in the four largest towns.

Region	Number	Stature cm.	Weight kg.	Rohrer's index
Northern Sweden	1379	174.2±0.16	67.7±0.18	1.28
Western Sweden	1051	175.8±0.19	69.6±0.20	1.28
Eastern Sweden	1724	175.4±0.15	69.0±0.16	1.28
Southern Sweden	1688	175.0±0.15	69.1±0.16	1.29
The four largest towns	735	177.5±0.22	68.9±0.24	1.23
The whole country	6577	175.4±0.08	68.8±0.08	1.27

and Northern Sweden the smallest which might be because the isolates are smaller in Northern Sweden than in the remainder of Sweden. However, the differences are not great. Body weight is more parallel to stature which is demonstrated by the fact that Rohrer's index for the different territories shows small deviations, except for the four largest cities where the conscripts were rather leaner. In other words weight matches stature.

We now pass to the foot measurements (see table 12). Again we find differences in the same direction as stature but not as pronounced. The greatest difference is between the four largest cities and Northern Sweden, where the difference in foot length amounts to 2.3 mm. while on the other hand there is scarcely any difference in foot breadth. The largest difference in foot breadth is found between the four largest cities and Southern Sweden where it amounts to 2.3 mm.

Now it is of most immediate interest to see if these differences have any connection with the variations in stature. We therefore also give from the stature calculated values for foot length and foot breadth. The difference between calculated lengths and observed ones are not worth mentioning. On the other hand there are some differences in the foot breadth. For the four largest cities the foot breadth is less than might have been expected from the length of the foot. The difference amounts to 1.6 mm. In the other groups also there are minor differences between calculated and observed foot breadth. These differences entail a slight displacement in the

Table 12

Observed and calculated foot measurements in men from different parts of Sweden and from the four largest towns.

Foot measurements	Region					
	Northern Sweden	Western Sweden	Eastern Sweden	Southern Sweden	The 4 largest towns	The whole country
Observed figures :						
Length of the foot	265.1 ± 0.33	267.6 ± 0.38	267.0 ± 0.30	266.4 ± 0.30	267.4 ± 0.46	266.6 ± 0.15
Breadth of the foot	105.8 ± 0.14	106.5 ± 0.16	107.0 ± 0.13	108.0 ± 0.13	105.7 ± 0.19	106.8 ± 0.07
Breadth in % of length	40.0 ± 0.05	39.8 ± 0.05	40.1 ± 0.04	40.6 ± 0.04	39.6 ± 0.06	40.1 ± 0.02
Tarsal width	255.7 ± 0.36	264.5 ± 0.41	263.1 ± 0.32	264.1 ± 0.32	262.7 ± 0.50	262.0 ± 0.17
Heel — tarsal width	338.8 ± 0.40	340.9 ± 0.46	340.7 ± 0.36	338.5 ± 0.36	339.8 ± 0.55	339.6 ± 0.18
Figures calculated on the basis of stature :						
Length of the foot	264.7	266.7	266.1	265.6	268.6	266.1
Breadth of the foot	106.3	106.8	106.4	106.5	107.3	106.7
Breadth in % of length	40.1	40.0	40.1	40.1	39.9	41.3

shape of the foot if it be taken as the breadth expressed as a percentage of the length. Conscripts from the four largest cities have narrower feet than those from other parts of the country which we as a matter of fact already have pointed out. The difference does not, however, exceed 1 % if the comparison is made in Southern Sweden between observed and calculated figures (which has the broadest foot) and it is therefore of small account.

If we finally consider the tarsal width and the heel-tarsal width, we still find insignificant differences between the territories (see table 12). The tarsal width is particularly small in northern Sweden. Then come the four largest cities. For the remaining territories the difference is still more insignificant. With respect to the heel-tarsal width we find the same state of affairs, i. e., the smallest measurements for northern Sweden. The differences are with regard to the standard errors without importance.

Summing up, we may say that no provincial differences of practical importance can be found. The actual differences are very small. The differences which actually can be found are merely of interest from a theoretical point of view. They can all be explained by the difference in stature.

Foot Build and Occupation.

It is particularly interesting to discover the relationship between foot structure and occupation. In so doing it must be remembered that the occupation at conscription will not necessarily be followed when military service is over. Naturally the job the conscript had when starting military service is not always the same as he had earlier in life. However, changes in occupation are certainly less common before military service than afterwards. In nonskilled occupations changes are more frequent than in skilled occupations which require special training. The occupation is, of course, of interest only if it conceivably might affect the structure of the foot. By aid of information received the material was divided into three groups. The first group comprises non-skilled labourers who do much walking and often have to carry heavy burdens. The second group is made up of industrial workers who work standing and who may be said to have a moderate load on the foot. The third and last group holds white-collar workers who, on the whole, work sitting down. Obviously the choice of occupation depends partly on the

constitution of the person concerned. A frail and delicate person just cannot be an unskilled labourer. Consequently it may be assumed that unskilled labourers are more heavily built. A similar selective process to some extent affects industrial workers versus white-collar workers, but this is not so pronounced and here the opportunities of getting the appropriate training plays a great part.

Table 13

Stature, weight and Rohrer's index for men with different occupations.

Occupation	Stature cm.	Weight kg.	Rohrer's index
Unskilled labourers	174.9±0.11	69.7±0.12	1.30
Industrial workers	174.9±0.14	67.9±0.15	1.27
White collar workers	176.8±0.16	68.4±0.17	1.24

Considering first stature and weight (see table 13) we find that the white-collar workers are taller while the two other groups have approximately the same stature. Unskilled labourers weigh more than industrial workers. White-collar men weigh almost as much as the unskilled labourers. If we consider the weight in relation to the stature (*Rohrer*'s index) we find that the unskilled labourers are heaviest in proportion to their stature. Then come the industrial workers and last the white-collar workers. Unskilled labourers apparently have the heaviest build, and they can therefore be expected to have the largest feet. The industrial workers come next while, seemingly, white-collar occupations are recruited by comparatively tall persons of more delicate build.

If we now consider the measurements of the foot (see table 14) we discover that unskilled labourers have the longest foot. The two remaining groups have approximately the same foot length. The breadth of the foot, on the other hand, decreases for all three groups. It is greatest for unskilled labourers and least in white-collar occupations. Accordingly the breadth expressed as a percentage of the length is greatest in the unskilled labourers, somewhat smaller in the industrial workers and least for white-collar occupations. The difference in the form of the foot is not large but quite significant.

Table 14

Observed and calculated figures for some foot measurements in men with different occupations.

Foot measurements	Occupation		
	Unskilled labourers	Industrial workers	White collar workers
Observed figures:			
Length of the foot	267.5±0.22	265.8±0.28	265.7±0.30
Breadth of the foot	107.7±0.09	106.3±0.12	105.5±0.13
Breadth in % of length	40.3±0.03	40.0±0.04	39.7±0.04
Tarsal width	263.1±0 25	261.8±0.30	259.9±0.33
Heel – tarsal width	340.6±0.26	338.8±0.35	338.8±0.38
Figures calculated on the basis of stature:			
Length of the foot	265.5	265.5	267.7
Breadth of the foot	106.5	106.5	107.1
Breadth in % of length	40.1	40.1	40.0

If due regard be taken to the stature, i. e. if we calculate the expected length and breadth of the foot in regard to stature of the person concerned, it appears that the calculated figure for the foot length is 2 mm. greater than the observed one in white-collar occupations. In industrial workers the expected and observed figures coincide. In unskilled labourers on the other hand the calculated figure is 2.2 mm. too low. In other words unskilled labourers have unexpectedly long feet and white-collar workers unexpectedly short feet. As regards the breadth of the foot we find that in the white-collar occupations it is actually narrower than calculations would indicate. For industrial workers the figures coincide. Unskilled labourers on the other hand have broader feet than could be expected. This shows that the deviations recorded cannot be due to differences in stature but are characteristic of a real difference. This difference applies to the foot particularly but may possibly be connected with the general body-build, for instance the fact that unskilled labourers can be expected to have wider shoulders and a sturdier build generally. Unskilled labourers have larger and broader feet while white-collar workers have especially narrow feet.

The differences found by us are particularly pronounced if the figures for the breadth of the foot are given as a percentage of the length. The percentage is largest for unskilled labourers, then come industrial workers and lastly white-collar men. The figures for tarsal width and heel-tarsal width exhibit similar differences. The greatest tarsal width is found in unskilled labourers, then come industrial workers and lastly white-collar occupations. As regards the heel-tarsal width also, we find the largest figure in unskilled labourers, but there seems to be no difference in this respect between industrial workers and office employees.

It is tempting to believe that these differences in the size and form of the foot are a direct consequence of the occupation. The feet should become larger and broader by being used more. As we have suggested above it is more probable, however, that we have to do with a selective phenomenon and that unskilled labourers have chosen their occupation because they had large feet and a powerful build. The comparatively narrow and short feet possessed by white-collar workers are almost certainly due to the same reasons as cause the greater stature. It is unlikely that persons who choose a sedentary occupation hereby are predestined to become somewhat taller. The greater stature in this group is probably due to the fact that they to a greater extent than the other groups come from more well-to-do parents who marry in a wider cross-section of the population. In other words, the reason probably is the breaking of barriers between homogeneous population groups, and, possibly, this is also the reason for differences in the size and form of the foot.

Foot Build and Working Posture.

We have now come to the point where it is interesting to asses the effect of posture, although, in so doing, we must keep in mind that selective elements play a decisive part in this connection. We have therefore divided the three previously studied occupational groups in relation to the posture necessitated by the work (see table 15).

We find that on the whole unskilled labourers carry on their work walking – a fact we have pointed out already. Most industrial workers do their job standing up while comparatively often white-collar workers spend most of their time sitting down. It is, by the way, natural that we here again come across the differences in stature and weight previously found between the different occupations.

Table 15

Weight and stature of men with different occupations, distributed according to walking, standing, or sitting posture at work.

Occupation	Posture at work					
	Walking		Standing		Sitting	
	Number	Mean	Number	Mean	Number	Mean
			Stature, cm.:			
Unskilled labourers	2432	174.9±0.12	215	174.2±0.41	136	176.3±0.52
Industrial workers	389	175.3±0.31	1181	174.9±0.18	155	175.4±0.48
White collar workers	407	176.2±0.30	245	175.7±0.39	763	177.4±0.22
			Weight, kg.:			
Unskilled labourers	2432	69.7±0.13	215	68.6±0.45	136	71.3±0.56
Industrial workers	389	68.7±0.32	1181	67.6±0.19	155	68.3±0.52
White collar workers	407	68.5±0.32	245	67.5±0.42	763	68.7±0.24

Table 16

Foot measurements in men of different occupations distributed according to walking, standing, or sitting posture at work.

Measurements of the foot	Occupation	Posture at work		
		Walking	Standing	Sitting
Length of the foot	Unskilled labourers	267.7±0.25	265.1±0.85	268.6±1.07
	Industrial workers	266.9±0.63	265.7±0.36	266.1±1.00
	White collar workers	265.8±0.59	265.3±0.76	265.7±0.43
Breadth of the foot	Unskilled labourers	107.8±0.11	106.5±0.36	108.1±0.46
	Industrial workers	106.8±0.26	106.1±0.15	106.3±0.41
	White collar workers	106.0±0.24	104.8±0.32	105.4±0.18
Breadth in % of length	Unskilled labourers	40.3±0.04	40.2±0.12	40.3±0.15
	Industrial workers	40.0±0.09	40.0±0.05	40.1±0.14
	White collar workers	39.9±0.08	39.6±0.11	39.7±0.06
Tarsal width	Unskilled labourers	262.1±0.28	262.7±0.94	266.3±1.18
	Industrial workers	262.3±0.67	261.5±0.38	263.3±1.06
	White collar workers	259.6±0.64	258.0±0.83	260.5±0.47
Heel-tarsal width	Unskilled labourers	341.1±0.30	338.9±1.00	342.0±1.26
	Industrial workers	340.6±0.77	338.7±0.44	340.1±1.22
	White collar workers	339.9±0.73	337.5±0.94	338.7±0.53

Proceeding to the measurements of the foot (see table 16) and considering the respective deviations for the different occupational groups we find that as a rule the differences are too small to be significant if the standard errors are taken into consideration. This implies that they to a large extent may be caused by random variation. There is, however, a significant difference with respect to the breadth of the foot in unskilled labourers who work standing up and those who walk amounting to 1.3 ± 0.4. The difference in foot breadth in standing and walking white-collar workers is 1.2 ± 0.4 and is consequently just significant. The breadth of the foot in percent of its length does, on the contrary, not exhibit any significant differences between sitting, standing and walking workers in different occupational groups.

For the tarsal width and the heel-tarsal width the differences are also insignificant. The sortings here made therefore support our belief that the amount of use to which the foot is subjected matters little for the size and form of the foot. Here it should be remembered that our material refers to young healthy persons who have been at work for a relatively short period only. Only 21 year olds are used in our material. That a prolonged load on the foot may, in individual cases, affect its form can, of course, by no means be denied on the basis of this material.

Foot Structure and Age.

During growth the size of the foot obviously changes along with the age. An adult can hardly expect any such change. A characteristic once acquired by the foot will in all probability be permanent. We have, however, already pointed out that the stature in different age groups in adult life exhibits some differences. The older age groups are somewhat shorter than the younger age groups not because of changes in ages but because of the increase in stature taking place in the Swedish people. On the average those born later are somewhat taller than those born earlier. The difference is not large (see table 2) but all the same quite clear.

Now the question is whether age can cause other changes in the size and structure of the foot than those conditioned by stature. With this in view we have investigated the measurements of the foot in 21 year olds and in individuals over 30. The number of old men included in our study are not many, and this is our reason for drawing the dividing line at this point. The 21 year olds number 6.625 and

Table 17

Foot measurements in men in two different age groups.

Measurements of the foot	Age	
	21 years	30 years and over
Total length of the foot, mm	266.6±0.15	264.2±0.58
Breadth of the foot between inner ball and outer ball, mm.	106.8±0.06	106.3±0.25
Width around the toes, mm	238.0±0.14	236.6±0.50
Width of the foot around the balls, mm	256.6±0.15	254.4±0.54
Tarsal width, mm.	262.0±0.17	253.3±0.54
Heel — tarsal width, mm.	339.7±0.18	344.3±0.78
Angle of the big toe with the longitudinal axis	5.6±0.05	7.7±0.25
Ball angle	112.1±0.03	112.2±0.13
Breadth of the foot in % of total length	40.1±0.02	40.3±0.09
Breadth of the foot in % of the width around the balls	41.6±0.01	41.8±0.05
% men with narrow foot type	31.6±0.6	29.0±2.1
% men with broad foot type	34.5±0.6	39.2±2.3

the men over 30 only 469. On the basis of table 17 a comparison may be made between the foot measurements in these two groups. We find that the length of the foot is less in the older group. The same applies to the breadth of the foot, although in this case the difference is insignificant. This implies that if we consider the breadth of the foot as a percentage of the length we get slightly higher figures for the older persons. From a statistical point of view the difference is merely probable, because the number of older persons is so small. It would seem, however, as though increasing age brought with it slightly broader feet. Part of the difference must be due to the slightly shorter stature of the older persons. This is owing to the fact, to be proved later, that the foot index (the breadth in per cent of the length of the foot) is so correlated to the stature that tall persons have a slightly smaller foot index than do short persons. The deviation in this respect is not quite large enough to account for the difference. Matters being as they are the deviation might, however, well be caused by random variation.

It is widely believed that the foot becomes flatter and broader with age. Whether or not this is true is impossible to say on the basis of our present material. The difference found is not significant, and, besides, the age difference between the groups we have available is hardly great enough to have any effect worth mentioning. The table furthermore shows that the angle formed between the big toe and the longitudinal axis of the foot increases with age. This means that the big toe gradually turns in towards the centre line of the foot. The natural explanation of this observation is that the foot becomes more compressed by the footwear. It is hardly probable that the increased angle depends on muscle tension. We have investigated the matter by stimulating the muscles with electric current and have found no evidence to support the theory that the angle can be changed by muscular contraction. We include a

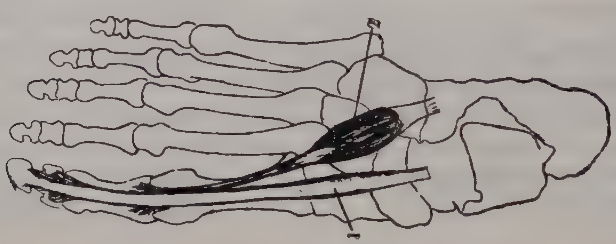

Fig. 3. Diagram illustrating the position of musculus extensor hallucis longus (1) and musculus extensor hallucis brevis (2) in regard to the big toe.

schematic diagram (fig. 3) which shows that the pull on the big toe of the muscles hardly is likely to affect the direction of the big toe in the horizontal plane.

Foot characteristics in users of arch-supports.

At the time of the first World War, the Surgeon General in England issued a report on "Defects Found in Drafted Men", in which it was asserted that 12 per cent of all men examined had flatfoot and that 2 per cent of the total number of rejections were for this cause. In the military statistics of Sweden is stated that 2.5 ‰ were exempted from military service on account of lasting reduced functional capacity of the lower extremities. However, no information is given about how many were exempted because they

had flatfoot, but obviously this number must have been rather small. In the present material on the other hand the frequency of men using arch supports is 5.7 %.

It is of some interest to discover whether users of arch-supports have foot characteristics that differ in any way with respect to the measurements taken for this study. We find that users of arch-supports have a greater average foot length than the others. The difference is 3.2±0.6 mm. (see table 18). On the other hand there is

Table 18

Comparison of some foot measurements in men with and without arch supports of the foot.

Foot measurements	Men with arch supports	Other men
	M±ε (M)	M±ε (M)
Length of foot	269.4±0.57	266.2±0.14
Breadth between inner and outer balls	106.7±0.24	106.6±0.06
Tarsal width	261.7±0.63	261.1±0.15
Ball angle	112.3±0.12	112.1±0.03
Transversal slope of heel	—0.1±0.09	—0.4±0.02

no corresponding increase in breadth. This implies that users of arch-supports have narrower feet. There is no difference in tarsal width. The transversal slope of the heel exhibits a difference amounting to 0.3±0.1°, i. e. the foot in users of arch-supports is inclined inwards; the foot takes a valgus position. We would recall that this measurement is very uncertain. The deviation found is, however, none the less significant, which is exactly what might have been expected.

As our material comprises quite a large number of users of arch-supports we have divided them into two groups: those who have used arch-supports for a year or less, and those who have used arch-supports longer than a year (see table 19). No difference was, however, found between these groups. Only with respect to the tarsal width is there a probable difference amounting to 3.4±1.3 mm.

Table 19

Foot measurements in men who have used arch supports of the foot less than a year, respectively more than a year.

Foot measurements	Arch support not over 1 year	Arch support over 1 year
	$M \pm \varepsilon$ (M)	$M \pm \varepsilon$ (M)
Length of foot	269.8 ± 0.73	268.8 ± 0.95
Breadth between inner and outer balls	106.9 ± 0.31	106.3 ± 0.37
Tarsal width	263.2 ± 0.86	259.8 ± 0.91
Ball angle	112.5 ± 0.16	112.1 ± 0.20
Transversal slope of heel	$+0.07 \pm 0.10$	-0.31 ± 0.15

The difference in the measurements of the foot in users of arch-supports and others are unexpectedly small except in regard to the length of the foot. It must be kept in mind, however, that a small number very flatfooted persons probably are excluded from the material. Individuals with clearly pathologic feet are exempted from military service.

We have then found that those using arch-supports have comparatively long and narrow feet. It is therefore of interest to compare their stature and weight with the stature and weight in the total material. It appears that in regard to the 470 persons who use arch-supports the mean stature is 175.7 ± 0.28, whereas for the total material the mean stature is 175.6 ± 0.07. In other words, there seems to be no difference. In regard to weight, however, we have found a significant difference amounting to 0.8 ± 0.27 (for the total material the weight is 69.1 ± 0.07, and for the flatfooted it is 69.9 ± 0.32). That the weight but not the stature is somewhat larger in the flat-footed involves a difference in *Rohrer*'s index. For the flat-footed the mean is 1.29 and for the total material it is 1.27. These figures show that those using arch supports are persons who are comparatively heavy for their stature. This possibly depends on their being fatter. It seems less probable that they should have an especially well developed skeleton. We have no possibility to decide, however, to what extent the increased foot length is an expression of a flattening of the arch.

The Interrelationship of the Foot Measurements.

Everybody knows that if a foot is unusually long it probably is especially broad. In other words the different foot measurements are correlated. But that is not all. There is also a relationship between foot measurements and other corporal measurements. Because of his stature a tall person may be expected to have larger feet than a short person. This reasoning may be carried still further by saying that a person with long arms, for instance, probably is extraordinarily tall and therefore in all probability has large feet. Considering the problem at large we may say that there is both a correlation of a rather general nature between different corporal measurements and consequently between different corporal measurements and foot measurements, and a special correlation between different foot measurements. This phenomenon is analogous to conditions in intelligence measurements where there partly are g-factors common to various tests and partly special factors which are common only to a small number of tests of the same type.

We shall now first discuss the general correlation, i. e. the correlation between foot measurements and the size of the body. The simplest way to characterize the size of the body is to give the stature and the weight. Naturally there is a correlation between these two measurements. The difference is that the stature does not increase after the age of 25 years, or thereabouts, when growth stops. The weight on the other hand may increase within certain limits thereafter also because of various environmental factors, but also owing to hereditary factors. From this we may throughout expect a stronger correlation between foot measurements and stature than between foot measurements and weight. The result of a calculation naturally depends on which age groups are being studied.

First we shall investigate the relationship between stature and foot length and foot breadth. In so doing we shall calculate the correlation coefficient according to Bravais-Pearson. In our material it is:

Stature – length of foot $r = 0.62 \pm 0.007$
Stature – breadth of foot $r = 0.38 \pm 0.009$

Evidently the correlation between stature and foot length is quite strong, but the correlation between stature and foot breadth is much weaker.

Table 20

Means of some foot measurements in men, distributed according to increasing stature.

Stature cm	Number of men	Length of foot, mm	Length to inner ball, mm	Breadth of foot, mm	Ball angle	Breadth in % of length	% men with narrow foot type
158—162	124	249.3	186.8	101.2	112.3	40.6	20
163—167	568	253.4	189.7	103.1	111.9	40.7	18
168—172	1889	259.6	194.3	104.9	112.1	40.4	25
173—177	2413	265.7	198.9	106.6	112.1	40.1	31
178—182	2146	271.7	203.3	108.0	112.2	39.8	38
183—187	852	277.1	207.2	109.4	112.1	39.5	45
188—192	182	283.8	212.3	110.5	112.2	39.0	54

To make matters clearer we give in table 20 figures for foot length and foot breadth with increasing stature. The figures show that both these measurements increase continuously with increasing stature but that in the classes of greater stature the increase of foot breadth is comparatively smaller. A consequence of this is that the foot index, i. e. the breadth as compared to the length, decreases slightly as the stature increases. The table also gives figures for the ball angle. As could be expected this proves to be quite independent of the stature. The figures just mentioned are merely intended as a background to those which have been correlated to the stature. Owing to the differences found in the length and breadth of the foot and their variation it is necessary to discover the character of this regression. We find that for stature and foot length it may be expressed by the following equation:

$$\textit{The length of the foot} = 241.9 + 1.185\ (S - 155)\ mm.$$

where S denotes the stature in cm. This regression equation was obtained by the method of least squares applied to the means of the foot lengths in the different stature classes. For the foot breadth we similarly obtain the following regression equation:

$$\textit{The breadth} = 99.0 + 0.442\ (S - 155) - 0.00325\ (S - 155)^2 mm.$$

where as before S denotes the stature expressed in cm. In other words the regression of foot breadth on stature graphically is not a straight line as it is with respect to foot length and stature. This difference can only to a very small extent explain that the correlation

between foot breadth and stature is weaker than that between foot length and stature. To clarify the meaning of the equations it may be pointed out that the foot length increases on an average 1.2 mm. for each cm. increase in stature (above 155 cm.) and that the foot breadth increases just above 0.4 mm. for the same increase in stature. In adult males the proportion between the increase in foot length and the increase in foot breadth is approximately 3 : 1.

If we know the standard deviation for the foot length and also the correlation between foot length and stature given by the coefficient r it is possible to calculate the standard deviation for the foot length at a certain stature from the formula:

$$\sigma_a = \sigma \sqrt{1 - r^2}$$

where σ = the standard deviation for the foot length and σ_a = the standard deviation at a certain stature. If, applying this formula, we calculate the standard deviation for the foot length in the stature class 173–177 cm., the one containing the mean, we find that $\sigma_a = 9.77$ mm. The σ_a found empirically in this stature class is 9.73 mm., the agreement thus being very good. If, in other words, it is desirable to order shoes with regard to stature only, the shoe must be approximately 3 cm. longer than the calculated mean for the feet to take care of all feet of persons with this stature. This piece of information is naturally of purely academic interest since nobody buys shoes according to his stature. It is merely given as an illustration of how things are.

Carrying out the corresponding calculations for the foot breadth we find a calculated variation for the same stature of $\sigma_a = 4.86$ mm. The variation found empirically is 4.84 mm. Consequently in this case also the agreement is very good.

Perhaps the most striking result of the ones discussed here is that the correlation between stature and foot breadth is weaker than between stature and foot length. However, the foot may be considered as a continuation of the leg and in several animals it is included in the length of the leg. And it is a fact that the length of the leg is very strongly correlated to stature. According to *Lundborg-Linders* (1926) the correlation coefficient is + 0.87, while on the other hand the correlation between the length of the trunk and stature is only + 0.18. Here it may be surmised that the genes causing tallness affect the long tubular bones rather than the short flat ones. The former bones have a pronounced zone of growth in

the epiphysis while the growth of the latter bones are not localized to a particular zone. Another way of stating this is to say that the long bones mainly grow unidimensionally while the short ones, e. g. the lumbar vertebrae, grow in all three dimensions. An even more arbitrary statement is that longitudinal measurements may be expected to have a stronger correlation to other longitudinal measurements than to transversal measurements. Further studies are of course required to warrant a general rule.

Table 20 shows another fact which we already have touched upon, viz. that with increasing stature the feet become narrower in relation to their length. The length-breadth index falls from 40.6 at a stature of 160 cm. to 39.0 at a stature of 190 cm. Although unimportant this deviation is statistically significant.

Since the size of the foot changes with stature, it must consequently also change with weight. As we know tall men generally weigh more than short men. We have calculated the regression equation for the weight. It is:

$$\textit{The length of the foot} = 244.15 + 1.297\,(W - 50) - 0.0062\,(W - 50)^2$$

where W denotes the weight in kg. For the sake of completeness we give table 21 which illustrates how the measurements of the foot change with the weight. By using a linear function fitting to the lengths in the middle weight classes we have found that the length of the foot increases by approximately 1.1 mm.

Table 21

Means of some foot measurements in men, distributed according to increasing weight.

Weight, kg.	Number of men	Length of the foot, mm.	Breadth of the foot, mm.	Ball-angle	Breadth in % of length	% men with narrow feet
53—57	230	250.1	100.3	112.3	40.2	29
58—62	1063	257.0	102.7	112.3	40.1	32
63—67	2126	261.8	104.7	112.1	40.1	32
68—72	2410	267.7	107.2	112.1	40.1	33
73—77	1448	272.9	109.2	112.1	40.1	32
78—82	679	277.3	111.1	112.1	40.1	32
83—87	194	281.7	113.4	111.7	40.2	30

above 250 mm. for each additional kg. in weight over 55 kg. A person weighing 75 kg. ought therefore to have a foot length of $250 + 20 \times 1.1$ mm. = 272 mm. This rule applies to weights between 55 and 85 kg. In dealing with higher weights this will not be so because then obesity without relationship to stature sets in.

Table 22

Coefficient of correlation between length of foot and other measurements of the foot.

Correlation between the foot length and the measurements given below	$r \pm \varepsilon$ (r)
Length of the foot to inner ball	0.94±0.001
Breadth between inner ball and longitudinal axis	0.39±0.009
Breadth of the foot between inner ball and outer ball	0.59±0.007
Breadth between inner ball and end of little toe	0.52±0.008
Distance between outer side of the heel and longitudinal axis	0.43±0.009
Distance between inner side of the heel and longitudinal axis	0.38±0.009
Width around the toes	0.48±0.008
Width of the foot around the balls	0.57±0.007
Middle tarsal width	0.53±0.008
Tarsal width	0.53±0.008
Heel — tarsal width	0.71±0.002
Angle of the big toe with the longitudinal axis	—0.02±0.011
Angle of the little toe	0.01±0.011
Ball angle	0.08±0.011
Inclination of the heel arch	0.07±0.011
Transversal slope of Achilles' tendon	—0.22±0.010
Transversal slope of the heel	0.21±0.011

We shall now pass on to a study of the relationship between foot length and other foot measurements. Table 22 gives the correlation coefficients. The table shows that the correlation between the total length of the foot and the length to the inner ball is 0.94±0.001. The foot length to the inner ball does, however, suffer from a relatively large error of measurement. If this were smaller the correlation would be slightly higher. But the high correlation is of course due to the foot length to the inner ball being the greater part of the total length. Here the strong correlation implies that the length of the foot to the inner ball is a fairly constant portion of the total

Table 23

Length to the inner ball in per cent of the total length of the foot, distributed according to different foot lengths.

Length of the foot mm	Length to the inner ball in % of total length
233—237	75.3
238—242	75.3
243—247	75.1
248—252	75.1
253—257	75.0
258—262	74.9
263—267	74.9
268—272	74.8
273—277	74.7
278—282	74.7
283—287	74.6
288—292	74.6
293—297	74.5
298—302	74.4

length. For short feet this portion is some 75 %. The percentage decreases slightly as the foot length increases, a fact illustrated in table 23. Conversely this implies that the toe length of long feet is only a slightly larger portion of the total foot length than is the case with short feet.

For this reason we can also expect a lower correlation between the foot length and the various breadth- and width-measurements. The correlation between foot length and foot breadth is 0.59 ± 0.007. Here, however, the correlation is comparatively strong. To illustrate conditions still further table 24 gives the observed standard deviation for the foot breadth at different foot lengths. The mean standard deviation is 4.3 mm. and the calculated standard deviation is 4.25 mm. Fig. 4 shows the quite exceptionally beautiful correspondence between observed and calculated values.

The correlation between the foot length and the distance from the inner ball to the longitudinal axis is only 0.39 ± 0.009. This distance, however, is comparatively difficult to determine exactly because it is only a part of the breadth of the foot. The error of measurement is 2.4 per cent of the mean and 35 per cent of the

Table 24

Observed standard deviation of foot breadth at different lengths.

Length of the foot, mm Class midpoint	Number of persons	Standard deviation of foot breadth
235	53	3.3
240	132	4.3
245	319	4.8
250	530	4.1
255	857	4.0
260	1248	4.2
265	1340	4.1
270	1211	4.4
275	999	4.3
280	684	4.4
285	441	4.6
290	235	4.2
295	100	3.9
300	43	4.7
Mean		4.3
Calculated standard deviation		4.25

standard deviation. Probably this is the foremost reason for the correlation being so much lower here than between foot length and foot breadth. The same is the case with the measurements of the heel breadth. These are also uncertain because the width of the heel was measured to the median line of the foot, i. e. divided into two parts.

As regards the correlation between the foot length and the different widths we find it is at the same level as the correlation between foot length and foot breadth. For the ball width it is 0.57 ± 0.007, for the middle tarsal width 0.53 ± 0.008 and for the tarsal width 0.53 ± 0.008. For the heel-tarsal width it is on the other hand larger, viz. 0.71 ± 0.002. This is understandable owing to the fact that the measurement in question in a manner of speaking is partly a longitudinal measurement since it is highly dependent on the length of os calcaneus.

The table also contains correlation coefficients between the length of the foot and some angular measurements. These merely

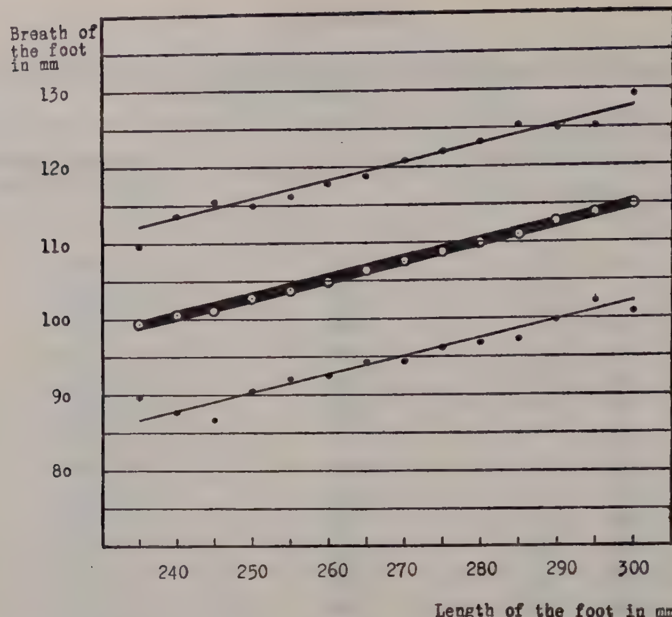

Fig. 4. Breadth at different lengths of the foot. The circles give the observed means of the breadth. The thin lines are calculated with the help of the correlation coefficient and signify distances of 3 σ from the means.

substantiate the expected fact that there is no correlation between foot length and angular measurements. The correlation between the measurements, is, on the whole, characteristic of the fact that the foot, irrespective of size, has a fairly constant form. The change in the form of the foot expressed by the falling foot index when the length of the foot increases is too small to affect the form of the foot appreciably. As a consequence the angular measurements cannot be noticeably correlated to the length of the foot.

Different Types of Feet.

In statistics one talks about various types in a distribution, particularly if the curve of distribution has two maximae. The concept may be used in other connections also. In everyday usage the word is rather loosely used. We talk of long and short types without defining where the dividing line goes. As a matter of fact such usage implies a rough distributive grouping much like when e talk about brachocephaly, mesocephaly and dolichocephaly.

Similarly we can talk of narrow, medium and broad feet. If we so divide the material, for instance, into three groups we are really doing nothing else than classifying a normal distribution. We have already shown that the foot index has such a distribution, i. e. there is neither excess nor skewness. If it is desirable to classify the material with respect to foot index we may well make the groups equally large and consequently divide the whole material into three parts. In doing this, one dividing line is drawn at an index of 39.2. Persons below this line are considered to have narrow feet. The upper limit is 40.7 which implies that persons between the two limits are considered to have medium feet and those above 40.7 have feet of the broad type. Table 25 shows how the feet are distributed by this arbitrary subdivision.

Table 25

Number of broad, medium broad and narrow feet at different foot lengths.

Length of the foot, mm	Narrow foot	Medium broad foot	Broad foot	Total
<240	1	10	61	72
240	9	32	91	132
245	35	99	185	319
250	73	165	292	530
255	156	291	410	857
260	310	437	501	1248
265	377	488	475	1340
270	475	408	328	1211
275	398	372	229	999
280	324	221	139	684
285	249	132	60	441
290	146	59	30	235
295	64	29	7	100
>295	47	15	2	64
Total	2664	2758	2810	8232

We now find that the foot types are unequally represented for different foot lengths (and for different stature, see table 20). Short feet are seldom of the narrow type while long feet seldom are broad. Feet of moderate length are equally represented among the three

Table 26

Percentual distribution of broad, medium broad and narrow feet at different foot lengths.

Length of the foot, mm	Narrow foot	Medium broad foot	Broad foot	Total	Breadth in % of length	
					Observed mean	Smoothed mean
<240	1	14	85	100	42.5	.
240	7	24	69	100	41.8	41.5
245	11	31	58	100	41.2	41.2
250	14	31	55	100	41.0	41.0
255	18	34	48	100	40.7	40.7
260	25	35	40	100	40.4	40.4
265	28	36	36	100	40.2	40.2
270	39	34	27	100	39.8	39.9
275	40	37	23	100	39.7	39.6
280	47	33	20	100	39.4	39.4
285	56	30	14	100	39.0	39.1
290	62	25	13	100	38.9	38.8
295	64	29	7	100	38.7	38.6
>295	74	23	3	100	37.9	.
Total	32.4	33.5	34.1	100.0	40.1	40.1

types. The percentage distribution by foot types is shown in table 26.

These percentages are, of course, slightly modified by random variation. They are at random too high or too low in comparison to figures from a more comprehensive material. The smoothed values are given in table 27 showing that medium broad feet have an almost constant representation of $^1/_3$ corresponding to the relative number of feet in the total material with a foot index between 39.2 and 40.7. For the commonest foot length (265–270 mm.) the three types are, as we see, equally represented. With the limits used here no very long feet are broad and no very short feet are narrow.

The relationship now described is of some theoretical interest and is a happy illustration of the association between the breadth and the length of the foot in our material. Table 28 gives a more concrete illustration of the same thing as it shows the distribution of narrow, medium broad and broad feet in the different types by shoe sizes. Among the small shoe sizes the broad foot is naturally

Table 27

Calculated percentual distribution of different foot types at increasing foot lengths.

Foot length mm	Narrow foot	Medium broad foot	Broad foot	Total
235	0	30	70	100
240	2	34	64	100
245	8	34	58	100
250	14	34	52	100
255	19	34	47	100
260	25	34	41	100
265	30	34	36	100
270	36	34	30	100
275	42	34	24	100
280	47	34	19	100
285	53	34	13	100
290	59	33	8	100
295	65	33	2	100
300	70	30	0	100

Table 28

Distribution according to type of foot at different shoe sizes.

Size of the shoes, No.	Number of men	Type of foot (%)			
		narrow	medium-broad	broad	Total
Not over 39	146	17.1	30.1	52.8	100.0
40	503	20.9	32.8	46.3	100.0
41	1274	24.1	34.4	41.5	100.0
42	2490	28.8	34.5	36.7	100.0
43	2381	35.8	33.9	30.3	100.0
44	1021	44.5	30.5	25.0	100.0
45 and over	406	49.7	31.3	19.0	100.0
Total	8221	32.4	33.5	34.1	100.0

better represented, while the narrow foot is better represented among the large sizes. Persons using the most common sizes, Nos. 42 and 43, according to the system used in Sweden, belong to the three types equally often.

Feet and Shoes.

By aid of statistical characteristics of the type published in this paper, it is, of course, no difficulty to calculate how many shoes of each type it is suitable to manufacture in order to satisfy the demand. The distribution by foot length directly gives the relative number in different length classes in adult men. By using the coefficient of the correlation between the length and breadth of the foot and the standard deviation for the foot breadth it is then possible to calculate how broad the shoes must be in the different length classes. Other measurements may be similarly used. For complete evaluation of the foot measurements in the different classes more correlation coefficients are needed than are published here. They have not been included because they hardly have any scientific importance. In this respect the practical problem is how broad the classes for the different measurements must be. The class interval depends on the tolerance allowed in, for instance, the width of the shoe, i. e. the difference between a shoe which just fits without squeezing and a shoe which is just not too wide to be used without discomfort. If the difference between these shoes, for instance with respect to the width is say 1 cm., this means that persons whose foot length is the same but whose feet will differ in width with at most 1 cm. (falling in the same class interval) will have to use the same width of shoe. The most suitable tolerance must, of course, be found empirically. If broader classes are taken than correspond to the tolerance, the result is that a number of persons will have to use shoes that are more or less uncomfortable from being too large. Of course, there is nothing to stop manufacturers from adopting narrower classes, it is purely a matter of expense. If the classes are too narrow an uneconomically large number of sizes will have to be produced.

In orthopedics it is said that the shoe must to some extent support the foot. A popular way of expressing this is to say that the shoe must be a kind of corset for the foot. It should, however, be pointed out that old worn-down shoes which do not press anywhere are most comfortable. Primitive peoples manage admirably without such corsets, whether they walk barefoot or in colder climates have some sort of footwear (red indians, esquimaux). In orthopedic quarters the retort to this is that the shod foot is not stimulated by the uneven ground in the same manner as the unshod foot. The muscles in a shod foot are not properly trained. The arches therefore

have a tendency to fall down unless the foot is supported at some points. It is said to be important that the shoe encloses the heel tightly and also encloses the anterior part of the foot immediately behind the basal phalanges of the toes. Support at these points is said to prevent to some extent the foot from being flattened.

As a matter of fact there are two theories of the mechanism of the foot. According to the old theory, the bones forming the longitudinal arch of the foot could be compared to a stone arch. In the support of this arch the principal part is played by the ligaments; the muscles are active only at movements. According to the modern theory the arch is supported by muscles and the ligaments only serve as safeguards; they come into action only when the muscular defence has broken down. An excellent survey of the investigations which have been carried out was given by *Norman C. Lake* (1943). Without taking up a position in these questions we only wish to point out that whether the arch is elongated or not at loading is deciding for the rôle the shoe plays. According to some investigations such an elongation does not seem to occur and then of course the shoe cannot be a support for the arch of the foot. However, the problems falling under this category can hardly be considered as completely solved.

It may be assumed that the demands imposed on the foot are far greater in military life than in civilian life. It is therefore particularly interesting to compare the shoe size used in military life with the shoe size used otherwise. Furthermore we can assume that esthetic elements are more important in civilian life than when doing military service. In Sweden much thicker footwear is used inside the shoe in military life than in civilian, and larger shoes are therefore needed. The thicker footwear mostly depends on the climate, but the wish to prevent too great strains on the skin during marches also plays an important part.

Civilian buyers of shoes have two conflicting requirements. Firstly they require shoes that fit the foot, i. e. which are not too small or too large. Secondly they demand shoes that appear to be small. For this reason shoes that are too small are often bought. This is perhaps especially true of women and young men. Fashion, finally, plays a certain part. Sometimes it may be the highest fashion with a so called French last, i. e. shoes that are comparatively long in relation to the width. At such times people with broad feet naturally have a difficult time. At other times so called American shoes with broad lasts may be modern. Now people with narrow

Table 29

Distribution of civil shoes according to size at different lengths of foot.

Foot length, mm	Number of men	Percentual number with different shoe sizes									Shoe size (means)
		not over 39	40	41	42	43	44	45	46 and over	Total	
243—247	319	14.8[1]	39.4	31.7	10.7	2.5	0.9	—	—	100.0	40.5
248—252	529	4.2	21.4	45.1	24.2	4.7	0.4	—	—	100.0	41.1
253—257	854	1.5	11.2	37.2	39.9	9.4	0.8	—	—	100.0	41.5
258—262	1245	—	4.7	26.4	50.6	16.8	1.4	0.1	—	100.0	41.8
263—267	1337	0.2	1.7	11.7	47.4	35.0	3.6	0.4	—	100.0	42.3
268—272	1210	—	0.5	5.8	35.1	47.1	10.5	0.9	0.1	100.0	42.6
273—277	999	—	0.2	1.2	21.1	53.1	20.6	3.7	0.1	100.0	43.0
278—282	684	—	0.1	0.1	8.8	46.3	36.5	7.7	0.5[2]	100.0	43.4
283—287	441	—	0.2	—	2.7	29.0	48.1	19.3	0.7	100.0	43.9
288—292	235	—	—	0.4	0.9	17.9	43.3	30.2	7.3[3]	100.0	44.2

[1]) of which 1.9 % size 38. [2]) of which 0.1 % size 47. [3]) of which 0.9 % size 47.

feet have the difficult time. They will have to put up with too large shoes.

If we first note which shoe sizes people use for the same foot length we find a large variation (see table 29). It seems possible to use about 6 different shoe sizes for approximately the same length of foot. Of course, this may be due to varying foot breadth for the same length so that it becomes necessary to choose a larger size, but possibly the inconsistent numbering systems used by the different manufacturers also make a difference. Not having sufficient data on shoe manufacturing we refrain from making any definite statement. The last mentioned state of affairs is, however, a source of error which plays some part in the following.

If we compare the distribution of feet by shoe sizes in civilian and military life, we find a shift upwards in military life. The mean for civilian shoes is 42.4 and for military ones 43.4. The average difference between civilian and military shoes therefore seems to be one size. To get a better perspective on the position we finally in table 30 give the percentage of men who use the same size of shoe in civilian and military life and those who use shoes, one, two, or at least three sizes larger in military life. The table shows that users of small shoe sizes seldom use the same size in military life. Only 1.4 % of those who use at most size 39 in civilian life use the same size in

Table 30

Comparison between military shoe sizes and civil shoe sizes.

Size of civil shoes.	Number of men	Per cent men with the same or larger military shoe sizes				
		Same size	One size larger	Two sizes larger	At least three sizes larger	Total
Not over 39	145	1.4	47.6	40.7	10.3	100
40	503	7.3	50.7	37.4	4.6	100
41	1270	5.8	68.3	24.4	1.5	100
42	2473	11.4	71.1	17.3	0.2	100
43	2378	17.8	68.8	13.1	0.3	100
44	1015	19.7	71.5	8.2	0.6	100
45 and over	399	33.8	57.7	8.5	—	100
Total	8183	14.1	67.7	17.3	0.9	100

military life, while among the users of size 45 and up in civilian life $^1/_3$ (34 %) use the same size in military life. It appears as though people with small feet were particularly prone to buying too small shoes. But this must in its turn have an explanation. As we have already mentioned narrow feet are usually long and broad types are common among short feet. This should imply that people with small shoes would be forced to choose shoes a size or two larger in military life than people who normally have large shoes. It is remarkable, however, that the displacement is as large as it is. Not less than 10 % of those with at most size 39 in civil life used shoes at least three sizes larger in military life. Among users of size 45 8.5 % take shoes two sizes larger. The part played by different sizing systems and different shoe shapes is impossible to evaluate. But a difference of this sort should hardly apply to small shoe sizes only. The displacement demonstrated can therefore not be explained by this phenomenon.

Feet and Shoe-making Lasts.

Even if the present investigation gives quite a good idea as to how the form of the foot varies, many important figures are missing. There is no direct measurement of the height of the foot. In substitution have been used partly the different measurements of width, and partly an index between the breadth of the foot and its width on level with the distal end-points of the metatarsal bones,

the so called ball width. It is, of course, difficult to devise satisfactory methods of taking these measurements, and naturally this is the reason why they were not taken. If we wish to reconstruct a foot on which measurements have been taken, it is of course all the better to have many measurements. Even in the most fortunate cases some useful measurement will always be missing since in practice the number of measurements taken must be limited. In making lasts on the basis of such measurements it is in other words necessary to use the imagination and the resulting last will always be slightly discrepant. It would perhaps therefore be better to adopt the following procedure.

On having decided which classes are necessary for the production of competitive shoes, persons are selected whose feet are near the upper borderline in the classes in the material. These feet are then reproduced in plaster of Paris. By suitable superficial corrections and possibly smoothing of these feet models absolutely true-to-life lasts are obtained. An adoption of this procedure would at any rate give better lasts than the ones now used in the footwear industry. These are always to some extent products of the imagination.

Summary.

We have not found any investigation into the variability of the foot. This problem was investigated on 8232 Swedish conscripts. 7 longitudinal and 6 angular measurements were taken with the aid of a specially constructed apparatus. Age, place of birth, occupation, weight and stature of the conscripts were also recorded.

By using double measurements it was established that the accuracy of the adopted measuring technique was satisfactory. The measurements taken were distributed according to a "normal" frequency curve. As results specially worth noting we give the following means and standard deviations:

foot length in mm	266.4 ± 0.14	12.5 ± 0.10
distance between inner and outer ball	106.6 ± 0.06	5.3 ± 0.04
ball width in mm	256.2 ± 0.14	12.4 ± 0.10
tarsal width in mm.	261.2 ± 0.15	13.6 ± 0.11
heel-tarsal width in mm	340.1 ± 0.16	15.0 ± 0.12
ball angle in degrees	112.1 ± 0.03	2.5 ± 0.02

As could be expected there was a marked correlation between the length of the foot and the stature. The existence of regional differences in regard to some measurements was investigated. The differences could be explained by difference in stature between the different districts. Similarly, the correlation between foot measurements and occupation and working posture was investigated. The small differences found could be due to selection when choosing occupation. Consequently, from our material there was no reason to assume that either the occupation or the posture necessitated by that occupation has any influence on the foot measurements.

No changes in the foot measurements with increasing age could be demonstrated. The differences actually present in the compared age groups (21 years and 30 years and up) was wholly attributable to differences in stature. In the higher age group the stature was shorter and the foot somewhat shorter. In both cases the breadth of the foot was more or less the same. This becomes clearer if the breadth is expressed as a percentage of the length (foot index). This index was somewhat lower in the case of the 21 year olds than in the case of those of 30 years and up. This discrepancy is explained by relationship between (stature) foot length and foot index. When the foot length (stature) increases the foot index falls which implies that long feet are comparatively narrower than short feet.

There is a strong correlation between the various length and width measurements of the foot. The angular measurements turned out to have no correlation with other measurements, which would indicate that the shape of the foot is relatively constant.

Résumé.

Nous n'avons pas trouvé d'autre travail concernant la variabilité du pied. L'étude du problème fut poursuivie sur 8232 recrues suédoises. Sept mensurations longitudinales et six mensurations angulaires furent prises à l'aide d'un appareil construit spécialement. Cinq mensurations circonférentielles furent également prises. L'âge, le lieu de naissance, le poids et la taille des recrues furent aussi notés.

On put établir que la précision de la technique de la mensuration adoptée était satisfaisante en pratiquant des mensurations à double. Les résultats obtenus se groupent selon une courbe de fréquence „normale“. Voici les résultats obtenus en moyenne et leurs déviations standard:

Longueur du pied en mm	266.4±0.14	12.5±0.10
Distance entre les éminences plantaires interne et externe	106.6±0.06	5.3±0.04
Circonférence passant par les éminences plantaires	256.2±0.14	12.4±0.10
Circonférence au niveau du tarse	261.2±0.15	13.6±0.11
Circonférence passant par le talon et le tarse	340.1±0.16	15.0±0.12
Valeur angulaire (degrés) interéminentielle	112.1±0.03	2.5±0.02

Comme on pouvait s'y attendre, il existe une corrélation nette entre la longueur du pied et la taille. L'existence de différences régionales fut également recherchée pour certaines mensurations; elles s'expliquent plutôt par des différences de taille suivant les régions. De façon analogue on rechercha une corrélation possible entre ces mensurations et la profession ou la position de travail. Les petites différences constatées peuvent être dues au hasard. En conséquence et en se basant sur notre matériel, on peut admettre que ni la profession, ni l'attitude corporelle qu'elle impose, n'exercent d'influence sur les mensurations du pied.

On ne put démontrer de modifications des mensurations du pied correspondant à l'âge. Les différences existantes dans les deux groupes d'âges comparés (21 ans et plus de 30 ans) peuvent être mises en relation avec des différences de taille: dans le groupe le plus âgé la stature était plus petite et le pied également. Dans les deux cas, la largeur du pied était plus ou moins la même. Cette relation devient plus nette si l'on exprime la largeur en % de la longueur (foot-index). L'index en question est un peu moins élevé dans le groupe âgé de 21 ans que dans celui dont l'âge dépasse 30 ans. Cette discrépance s'explique par la relation entre la longueur du pied (stature) et l'index. Lorsque la longueur du pied (stature) augmente, l'index s'abaisse, ce qui indique que les longs pieds sont relativement plus étroits que les courts.

Il y a une relation étroite entre les diverses mensurations de largeur et de longueur du pied. Les mensurations angulaires sont sans rapport avec les autres mensurations, ce qui semble indiquer que la forme du pied est relativement constante.

Zusammenfassung.

Untersuchungen über die Variation des Fußes konnten wir nicht finden in der Literatur. Um eine Auffassung über die Größe des Fußes und die Variation der Fußmaße zu erhalten, wurden 8232 schwedische Soldaten untersucht. Mit einem zu diesem Zwecke besonders konstruierten Meßapparat wurden 7 Abstands- und 6 Winkelmessungen vorgenommen. Außerdem wurden fünf Umfangsmessungen gemacht. Alter, Geburtsort, Beruf, Gewicht und Körpergröße der Untersuchten wurden angezeichnet.

Durch Doppelmessungen konnte konstatiert werden, daß die angewandte Meßtechnik im großen ganzen zufriedenstellend war. Sämtliche Maße verteilten sich wie eine „normale" Frequenzverteilung. Aus den Resultaten können folgende Mittelwerte und Streuungen angeführt werden:

Länge, mm	266.4 ± 0.14	12.5 ± 0.10
Breite zwischen Innen- und Außenballen, mm	106.6 ± 0.06	5.3 ± 0.04
Ballenumfang, mm	256.2 ± 0.14	12.4 ± 0.10
Ristumfang, mm	261.2 ± 0.15	13.6 ± 0.11
Fersen-Ristumfang, mm	340.1 ± 0.16	15.0 ± 0.12
Ballenwinkel, Grade	112.1 ± 0.03	2.5 ± 0.02

Wie erwartet, konnte ein ausgeprägter Zusammenhang zwischen Fußlänge und Körperlänge festgestellt werden. Gewisse Fußmaße wurden innerhalb gewisser Landstriche untersucht, wobei sich gewisse Unterschiede zeigten, die parallel mit den Unterschieden in der Körperlänge liefen. Außerdem wurde der Zusammenhang zwischen Fußmaßen und Beruf, bzw. Körperstellung untersucht. Kleinere Unterschiede, die sich zeigten, konnten durch Auswahlsmomente erklärt werden. Es ist demnach nicht wahrscheinlich, daß Beruf oder Körperhaltung bei der Berufsausübung auf die Fußmaße einwirken.

Eine Veränderung der Fußmaße mit steigendem Alter konnte nicht nachgewiesen werden. Verschiedenheiten, die zwischen den verglichenen Altersgruppen (21 Jahre und 30 Jahre und mehr) vorlagen, konnten zur Gänze durch Verschiedenheit in der Körpergröße erklärt werden. In der höheren Altersgruppe war die Körperlänge kleiner und der Fuß etwas kürzer. Die Breite war in beiden Altersgruppen ungefähr dieselbe. Dieses Verhältnis tritt besonders

deutlich hervor, wenn die Breite in % von der Länge ausgedrückt wird (Fußindex). Dieser Index war etwas kleiner für 21jährige als für 30jährige und ältere. Dies kann durch den Zusammenhang, der zwischen (Körpergröße) Fußlänge und Fußindex besteht, erklärt werden. Bei steigender Fußlänge (Körpergröße) sinkt der Fußindex, d. h. daß lange Füße verhältnismäßig schmäler sind als kurze.

Die verschiedenen Abstands- und Umfangsmaße des Fußes stehen in engem Zusammenhang. Die Winkelmaße zeigen keinen Zusammenhang mit den übrigen Maßen; das letztere würde daraufhin deuten, daß die Form des Fußes verhältnismäßig gleichbleibend ist.

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DO PARENTS WANT BOYS OR GIRLS?

by GUNNAR DAHLBERG

It may be thought that the question as to whether parents want boys or girls is not of great interest. Nothing can be done about the matter at present. It happens as it happens.

However, the matter is not an indifferent one from a theoretical point of view. The question primarily discussed among statisticians concerned with population problems is to what extent parents desire to replace a child which dies and whether this desire is stronger after the death of a boy or that of a girl. The simplest way of getting information as to the wishes of the parents is by asking them directly. However, so far as I know, this method has never been used but people have been content to try to deduce tendencies and draw conclusions from the figures which happened to be available.

Furthermore the question is of interest from a general psychological point of view. It might be possible to obtain some information as to what motives are predominant in matters concerning fertility by asking such questions.

Finally, it is not excluded that, in the future, it will be possible to influence the proportions of the sexes and to control the sex of the unborn child. We know that there are two sorts of spermatozoa, one leading to the production of males and the other to that of females. It is possible that, in the future, a way will be found of separating the two sorts of reproductive cells and thus of determining sex at least at artificial fertilization. Some workers have already made attempts to do so and report that they have achieved successful results. These reports, however, do not seem very convincing. The problem must still be considered as unsolved, but this does not mean that it will remain so.

With these points in mind I have had information collected as to whether parents want boys or girls. The mothers were asked before their confinements whether they wanted a boy or a girl or whether they were indifferent. They were also asked which the fathers wanted. The material was collected at the Academic Hospital

Table 1.

Wishes of the parents as to the sex of their children. Absolute numbers.

Wish of: Mother	Wish of: Father	None previously: Boy	None previously: Girl	Only or mostly boys: Boy	Only or mostly boys: Girl	Only or mostly girls: Boy	Only or mostly girls: Girl	Equal numbers of boys and girls: Boy	Equal numbers of boys and girls: Girl	Total: Boy	Total: Girl	Total: Total
Boy	Boy	57	41	6	1	72	57	6	4	141	103	244
	Girl	5	5	0	3	1	1	0	0	6	9	15
	Indifferent	10	10	3	0	6	3	2	1	21	14	35
Girl	Boy	33	27	6	6	4	3	2	3	45	39	84
	Girl	32	37	69	67	2	4	4	9	107	117	224
	Indifferent	14	10	6	6	1	3	1	3	22	22	44
Indifferent	Boy	25	24	2	2	9	11	1	1	37	38	75
	Girl	7	5	4	2	0	0	0	1	11	8	19
	Indifferent	46	37	16	6	23	9	13	17	98	69	167
	Total	229	196	112	93	118	91	29	39	488	419	907

Table 2.

Wishes of the parents as to the sex of their children expressed as percentages with standard error.

Parents' wishes	None previously	Only or mostly boys	Only or mostly girls	Equal numbers of boys and girls	Total
Both want a boy	41.4 ± 3.2	4.4 ± 1.6	89.5 ± 2.5	35.7 ± 9.1	43.0 ± 2.1
Both want a girl	29.1 ± 3.0	86.1 ± 2.8	4.2 ± 1.7	46.4 ± 9.4	39.5 ± 2.1
Father wants a boy, mother a girl	25.3 ± 2.9	7.6 ± 2.1	4.9 ± 1.8	17.9 ± 7.2	14.8 ± 1.5
Mother wants a boy, father a girl	4.2 ± 1.5	1.9 ± 1.1	1.4 ± 1.0	—	2.7 ± 0.7
Total	100.0	100.0	100.0	100.0	100.0

in Uppsala and at the General Hospital in Malmö. I wish to thank Professor *Naeslund* and Docent *Lennér* for their great kindness in allowing me to obtain this information.

Tables 1 and 2 give a synopsis of the information obtained.

It is seen that 45.5 % of the mothers, i. e. 294 out of 646, wanted a boy whereas 61.0 % of the fathers, i. e. 403 out of 661, wanted a boy. In 261 cases out of 907, i. e. 28.8 % the mother had no definite wish in the matter and in 246 cases out of 907, i. e. 27.1 %, the father had no definite wish or if he had it was not known.

The wishes of the parents as to the sex of the unborn child may be determined by short-termed motives, as for example the belief that girls are easier to bring up, or that boys are healthier and more enterprising. It seems as though there were a tendency for people to prefer their own sex. The mother to a small extent prefers a girl while the father more often prefers a boy. The motives for preferring one sex or the other may also be of a more long-term nature. It may be considered that boys have greater opportunities of making a success of their lives in the community when they are grown up. Men have greater opportunities of advancing themselves by their own efforts. But it may also be conceived that girls have fewer worries in life than boys if they get married. It is of special interest from this point of view to note the wishes of those who have no previous children. It is found that in such cases 54.4 % out of 281 mothers want a girl while 69.5 % out of 298 fathers want a boy. In other words one gets the impression that, so far as the first child is concerned, the father is most often influenced by long-term motives, though perhaps not so much as might have been expected. On the other hand it looks as though the mother were most influenced by thoughts of the immediate future and wished for a girl. In any case it seems that the idea which appears to have been prevalent in the old days, namely that boys are greatly to be preferred to girls, no longer carries any weight among mothers. In investigating the wishes of those who already have children (living at the time when the questions are asked) the material must be divided according to the sex of the previous children. The material has thus been divided into three groups, those who have previously only had boys or a majority of boys, those who have previously only had girls or a majority of girls, and finally those who have equal numbers of children of both sexes.

It is now found that those who already have one or several boys almost always (i. e. in 86 % of the cases) want a girl while those whose families consist entirely or predominantly of girls usually want a boy (i. e. in 89 % of the cases). In other words it is not the case that a greater desire for boys prevails regardless of the circumstances. Among childless couples the father would prefer a boy while the mother would prefer a girl. In the case of later children the wishes are influenced by the sex of the previous children. People want to have both sexes represented among their children. This does not suggest that long-term motives play a part in determining their wishes. People have not, in fact, come to the conclusion that, on the whole, members of one sex or the other have a better life, nor do such factors determine the parental desires. People are probably most concerned with the pleasure to be derived from the children while they are young. If they have a boy they want a girl and *vice versa* in order that both sexes may be represented with all their advantages and disadvantages.

It appears that long-term motives do *not* play a very large part in this connection, and this is important for those who want to carry out propaganda in connection with the population problem. People will remain unmoved by what may happen in the long run, the community's need for labour power in the future etc. Furthermore it is remarkable that fertility rose in Sweden during the Second World War when it would rather have been thought that the general situation would have made people afraid to have a family. Everybody thought the danger of war very great. This evidently had no great influence on people.

For the sake of completeness it must be mentioned that in 20 % of the cases where the parents had no previous children they had no definite wishes in the question of sex. In cases where the previous children were entirely or predominantly of one sex only 13 % expressed no definite wish. On the other hand, it is comparatively common for the parents to be indifferent when the previous children consist of about equal numbers of boys and girls. No fewer than 44 % expressed no definite wish. In other words, it looks as though the parents were rather less interested in the sex of the first child than in that of the later ones except in cases where the previous children consist of the same number of boys and girls.

Another interesting point is that the parents appear usually to be agreed at least on this matter. It is less usual for the father to

want a girl and the mother a boy or *vice versa*. The greatest difference between the wishes of the parents occurs in the case of the first child. After this there is fairly good agreement.

It may further be pointed out that wishes naturally do not affect the actual sex of the child. Half are boys and half girls with such deviations as are to be expected on grounds of chance.

Summary.

By asking the mother just before the birth which sex she and her husband wish the child to have, information is obtained in 907 cases. The fathers desire a little more often a boy than a girl, the mothers have the opposite wish though not so strong. If the parents have children before, they generally wish the new child to have a different sex. This seems to imply that parents are not influenced by a longer view of the children's prospects.

Résumé.

Chez 907 femmes sur le point de donner le jour à un enfant, on posa la question de savoir de quel sexe elle-même et son mari désireraient que fût l'enfant. Les pères désirent un peu plus souvent un garçon qu'une fille, les mères expriment le voeu opposé mais pas aussi nettement. Si les parents ont déjà des enfants ils désirent que l'enfant à naître soit d'un sexe différent. Cette enquête semble indiquer que les parents ne sont pas influencés par les perspectives d'avenir de leurs enfants.

Zusammenfassung.

Auf die Frage an die Mutter, gerade vor der Geburt, welches Geschlecht sie und der Vater für ihr Kind wünschen, wurden in 907 Fällen Informationen erhalten. Die Väter wünschen etwas häufiger einen Knaben als ein Mädchen, die Mütter haben den entgegengesetzten Wunsch, aber nicht so intensiv. Wenn die Eltern schon früher Kinder haben, wünschen die meisten ein anderes Geschlecht für das neue Kind. Dies scheint zu bestätigen, daß der Wunsch der Eltern nicht durch den größeren Gesichtspunkt, nämlich der Zukunftsaussichten der Kinder, beeinflußt wird.

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A PEDIGREE SHOWING THE INCIDENCE OF MALFORMATION OF THE NIPPLES

by TORSTEN ROMANUS[1])

Malformations of the nipples have chiefly attracted the interest of obstetricians as they may provide an obstacle to suckling. The approximate frequency of malformations of the nipples may be seen from the figures quoted below.

		No. of cases	Flat and inverted nipples in %	Inverted nipples only in %	Mamilla invertita*) only in %
Dluski	1894	302	6	4.7	–
Jaschke	1917	200	8	5.3	0.5
Zander	1908	1000	–	–	0.5

*) According to *Basch* 1893. Also called papilla circumvallata obtecta.

"Mamilla invertita" is thus not at all common.

While the genetical literature concerning accessory nipples, for example, is fairly comprehensive, communications are very seldom made concerning malformations of the nipples.

Heizer 1932 described 5 cases with only one teat on the left side in 5 generations of cattle. The same malformation occurred in another family of cattle distantly related to that mentioned above, but this time on the right side. *Heizer* considered that the inheritance of this malformation was very probably recessive. He states that *Turner* 1931 also described a similar case. Inverted nipples in swine is described by *Nordby* 1934. According to him the data seem to indicate recessiveness. *Stotsenberg* (according to *Donaldson* 1924) found in Mus Norwegicus cases where only six of twelve nipples were

[1]) The author wishes to thank Dr. *Gösta Odstedt*, who first observed the anomaly in the breast of the proband who was his patient, for referring the case to him.

present and he has been able to carry a deficiency through four generations. *Little* and *McDonald* 1945 have made an investigation of abnormalities of the mammae in Mus musculus. They found that the frequency of symmetric or asymmetric deficiency in number of mammae in eight stocks varied from 0 to 8 per cent. About the transmission they say that there are very characteristic patterns of deficiency for each stock of mice but little evidence of transmission of the defects from mother to daughter.

Prochownik 1909 mentions in a lecture that he was able to follow mamilla invertita through three generations in three families where it was inherited regularly as a dominant character. *Siemens* 1924 found a slight degree of inversion of the nipples in both of two pairs of unioval twins, in one case 5 year old brothers and in the other 16 year old sisters. In Handbuch der Erbbiologie des Menschen *Wehefritz* 1940 states, without giving references that it is to be supposed that mamilla invertita is hereditary owing to its presence in both of unioval twins. (He is probably referring to the cases described by *Siemens*). *Liebenam* 1938 records in one of a pair of monozygotic female twins a complete absence of the right breast and nipple and pectoralis major.

The family here in question consists of 70 people directly descended from a common ancestor and comprises 4 generations. 45 of the persons are 15 years old or over. A short description of the pathological findings is given below. The figures refer to the numbers given to the persons in the pedigree (see fig. 1).

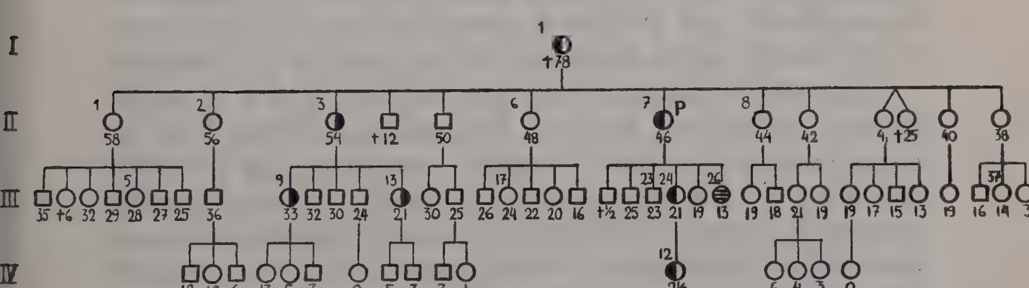

Fig. 1. Pedigree of the family with anomalous nipples. The following symbols are used: Man = open square; Woman = open circle; Twins are marked with a connecting angle; Proband = P; Figures under the symbols = age in years; Figures over the symbols = number in the case histories; Mamilla invertita dexter = circle with left half filled; Mamilla invertita sinister = circle with right half filled; Papilla fissa bilateralis = striped circle.

List of cases showing anomalies of the nipples.

I	1.	Woman.	Died aet. 78. Stated to have had inversion of the nipple.
II	3.	Woman.	Aet. 54. Stated to have inversion of the left nipple.
II	7.	Woman.	Aet. 46. Proband. Seen personally by the author. Right mamilla invertita (see fig. 2).
III	9.	Woman.	Aet. 33. According to the hospital case notes had left mamilla invertita.
III	13.	Woman.	Aet. 21. Stated to have left mamilla invertita.
III	24.	Woman.	Aet. 21. Seen personally by the author. Left mamilla invertita (see fig. 3).
III	26.	Girl.	Aet. 13. Seen personally by the author. Bilateral papilla fissa levis.
IV	12.	Girl	Aet. 2½. Seen personally by the author. Right nipple flush with the skin, left nipple protrudes about 2 mm.

(The following cases were stated to suffer from "migraine". Those described as "typical" had attacks of unilateral headache associated with scintillating scotoma and malaise: I, 1 typical; II, 1; II, 2 typical; II, 6 typical; II, 7 typical; II, 8 typical; III, 5; III, 17; III, 23 (man) typical; III, 24 typical; III, 37 typical.) These cases will not be discussed here as the concept of migraine is not completely clear and the diagnosis may often be uncertain as it rests entirely on the description by the patient of his symptoms.

Case III, 9 is worthy of note from the point of view of surgical diagnosis. In this case there was left mamilla invertita. When tumours arose in this breast a radical mastectomy was performed presumably because the tumours were thought to be carcinomatous owing to the retraction of the nipple. The morbid anatomical diagnosis however, was adenofibroma. Further tumours arose later in the right breast and a biopsy was performed. The diagnosis was interstitial mastitis.

According to this pedigree mamilla invertita is inherited regularly as a dominant character. Concerning the localisation of the anomaly, in the original ancestor I, 1, it was right-sided, and it retained this localisation in the proband II, 7, and in one of the

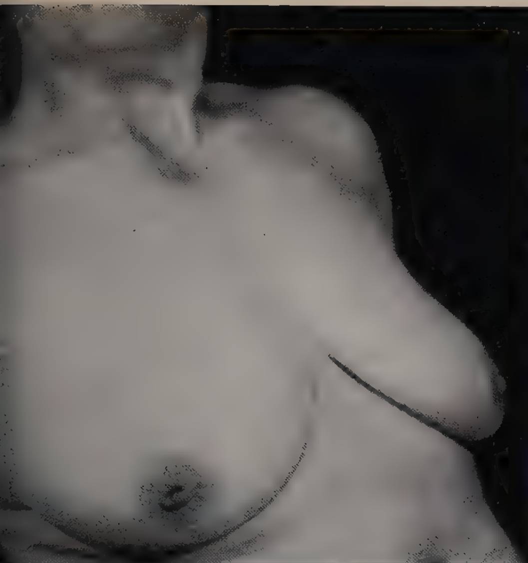

Fig. 2. The proband (No. II : 7 in the pedigree).

Fig. 3. One daughter of the proband No. III : 24 in the pedigree).

proband's daughters III, 24, and possibly even in her daughter IV, 12 as well. The localisation had changed and become left-sided in another daughter II, 3 of the original ancestor, and also in her two daughters III, 9 and III, 13. It is also interesting to note that another daughter of the proband III, 26 had bilateral papilla fissa.

According to *Dahlberg* 1948 it is reasonable to classify the factors which cause the cell proliferation in three groups: hereditary factors, environmental factors and factors due to random variation. A rough idea of factors which have a random effect may be obtained by measuring differences between left and right side. When the asymmetries vary they are called facultative. *Dahlberg* proposes that the term "penetrance" should be used only for the effect of these random factors. In the case here described the asymmetries change side only in different branches of the pedigree and therefore they possibly are genotypic asymmetries (*Dahlberg* 1926 and 1943).

It is of interest from the obstetric point of view that the anomalous nipples did not prevent their possessors from bearing many children (see pedigree) whom they suckled themselves. It was stated

that the babies naturally had some difficulty in drawing the milk from the anomalous nipples for themselves, but in such cases the breast was emptied manually.

Summary.

Several cases of malformation of the nipples in the members of a family consisting of 70 persons indicate dominance. The anomaly sometimes appears on the right side, sometimes on the left one, though cases with malformation of the nipples of both breasts also exist. The reason of the asymmetry is discussed.

Résumé.

Dans une famille groupant 70 personnes, l'apparition de „mamilla invertita“ fait penser qu'il s'agit d'un caractère dominant. L'anomalie survient parfois à gauche, parfois à droite mais il y a aussi des cas bilatéraux.

Discussion de la cause de cette asymétrie.

Zusammenfassung.

Das Vorkommen von Mamilla Invertita bei einer Familie, die 70 Personen umfaßt, läßt auf Dominanz schließen. Die Anomalie tritt manchmal rechtsseitig, manchmal linksseitig auf, doch gibt es auch doppelseitige Fälle. Die Ursache für diese Asymmetrie wird diskutiert.

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NOTES ON THE CONCEPTION OF TYPE

by GUNNAR DAHLBERG

In statistics when we speak of the type of a distribution we simply mean the peak of the distribution, i. e., the maximum of the curve, which is also called the mode. In a symmetrical distribution the maximum coincides with the mean and the median. In a so called skew distribution these are separate quantities, and in such cases the mode (M_o) can sometimes be calculated from the difference between the median (M_d) and the mean (M) by means of the following formula:

$$M_o = 3\ M_d - 2\ M$$

In a distribution with several modes, one that is bi- or multimodal, we have to do with several different types. Care must of course be taken that the peaks are not due to an insufficient material and caused by random variation, but that they truly characterize a tendency to form several peaks. In any case the statistical definition is unequivocal.

In speaking of different anthropological types, the meaning frequently is quite different. If, for instance, we talk about dolichocephalics, mesocephalics and brachycephalics, there is no implication that these types represent peaks in the distribution. We are merely availing ourselves of a very rough classification which in a measure is subjectively defined. We might as well use the terms short, medium tall and tall types with respect to stature.

We often talk of different types when we are dealing with a combination of characteristics. It has long been attempted to combine certain bodily properties with definite psychic traits. Actually this typology goes far back and it probably has its roots in the ancient doctrine of the four temperaments. When it comes to a classification of temperament, the system of the astrologers also has left traces in our speech. We still describe people in planetary terms as jovial, mercurial, saturnine, martial etc. In recent times practically every country has developed its own system as to body build and temperament. In Italy, for example, we have *Viola* and *Pende* and in France, *Rostan* and *Sigaud*. The system evolved by the German

Kretschmer is best known throughout Europe. Of late *Sheldon's* system, which is essentially similar to *Kretschmer's*, has evoked much interest in America. In principle these systems are based on the fact that there is a more or less definite connection between various physical and psychical characteristics. Some aspects of this connection are simply explained. That a person who is unusually fat, and therefore is characterized by rotundity of body, is especially interested in food, is *per se* understandable. Obviously there must be a correlation between great appetite and obesity, and, conditions being equal, the greater the appetite, the more marked the obesity. That such persons would like as a rule to eat good dinners is rather obvious. Other correlations between the aforementioned physical and psychical characteristics are more difficult to fathom. Since it is difficult to measure psychical characteristics, it is obviously also difficult to objectively prove a correlation between physical and psychical characteristics. No doubt many statements made with regard to so called bodily types are little better than misstatements. To this must be added that the influence of age on bodily structure has not always been taken into due account. On the whole increased age involves a tendency to increased weight and a rounder figure. In studying these matters we must therefore see to it that we are dealing with persons of the same age. The part played by age appears clearly from the schematic figure given in *Kretschmer's* book. It is easy to see that the persons who represent various ideal types in his figure by no means are of the same age.

As an example of an investigation wherein the influence of age is taken into due account, we shall mention the one done by *C. R. Garvey* (1933). The author could not demonstrate any difference in the bodily types of persons suffering from schizophrenia and those suffering from manic-depressive dementia. This is definitely contradictory to the system of *Kretschmer* which is based on the supposed affinity between his types and these two forms of mental disease.

If a rough classification is adopted, it is of course easy to differ between fat and lean individuals, although we hardly have a satisfactory means of assessing fatness. The rough classification is to a certain extent warranted by the lack of an exact method of measuring. For the same reason we may distinguish between powerful and feeble persons with regard to muscular development. A combination of these two groupings should actually result in four groups: 1. Lean

and feeble persons. Of old these are called asthenics. *Kretschmer* calls them leptosomes. *Sheldon* uses the term ectomorphs. 2. Lean powerfully built persons. There is no traditional term for this type. *Kretschmer* calls them the athletic type, *Sheldon* calls them mesomorphs. 3. Fat persons with feebly developed muscles. These are traditionally called apoplectics the reason being that they are most common among old people. *Kretschmer* calls them pycnic, *Sheldon* endomorphic. 4. Fat muscularly powerful individuals. Strangely enough this group has never been given any special name. The explanation is probably that if the obesity is very accentuated it is difficult to establish whether the muscles are well developed and that they therefore have been classed with the former group. If, however, the obesity is not so extreme, they are put in the athletic group.

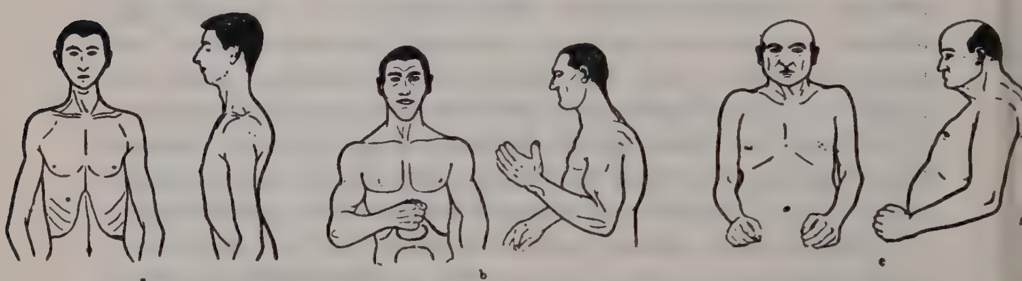

Fig. 1. Schematic drawing of the three types: a) leptosome, b) athletic, c) pycnic. The figures are taken from *E. Kretschmer*'s book "Körperbau und Charakter" (1942). Observe the age difference in the types. With slight alterations they could be the same person at different years of age.

During the many years that these problems have occupied the attention of anthropologists more objective methods have gradually been evolved and adopted. Already *Kretschmer* to some extent used measurements to find a sound basis for his system. *Sheldon* was more intent on using statistical methods. On account of the psychological characteristics included in the classification, such systems, however, are a little inexact and vague. Therefore they give room for subjective opinions, and moreover, they appeal to the popular imagination. As a matter of fact, one has often tried to bolster up such systems with literary quotations. Especially *Shakespeare*'s Julius Caesar has been quoted: "Let me have men about me that are fat; sleek-headed men, and such as sleep o' nights." Naturally no slight at *Kretschmer* or *Sheldon* is implied hereby. "They are honourable men."

They fight for freedom necessary for creative thinking which unfortunately sometimes seems to be the same as freedom for loose thinking.

The objection to be raised against systems of this kind is that they are very primitive methods of showing a correlation when using rough classifications. Under such circumstances, of course, the correlation found is very dubious. On account of the vague methods the problem is invested with mystical features similar to the conception of race. With regard to psychical characteristics the difficulty of measuring is, of course, a defence, but the very fact that it is impossible to measure leaves room for subjectivity and makes the system less scientific.

This mysticism has to some extent overshadowed the intrinsic problems and prevented interested persons from arriving at more objective methods. The problems are made more complicated than they really are. Supposing that a similar system had been evolved using stature and bodily weight, a correlation, if any, with physical characteristics would have been demonstrated by using more rational statistical methods. More or less queer statements would not have been advanced on very weak grounds, even if one had distinguished between a brevi-levi type and a longo-levi type, nor would various imponderabilities have been ascribed to them.

To illustrate our point of view we shall give a further example. In regard to the foot, the breadth increases when the length increases. To begin with this increase is rather rectilinear. When the foot has come up beyond a certain length, however, the increase in breadth becomes comparatively small. In other words, the regression curve is curve-linear. If we now divide up the feet into narrow, medium broad and broad types, we find that on an average the narrow types are longer and that among the long types there are practically no broad feet. Since the foot size is correlated with the stature, this means that tall persons practically never have broad feet but on the contrary have narrow or medium broad feet. This is the consequence of the curve-linear regression. To discuss types would of course be a more primitive way of expressing the matter, especially as it would be easy to misunderstand this, and believe that people have different kinds of feet.

The example has been chosen in order to show that it is possible to complicate a problem simple in itself when using the conception of type. The example has been taken from *Dahlberg* and *Lander:* Size and Form of the Foot in Men (1949).

Summary.

The conception of different body types is discussed and found to be a primitive method of showing correlation by using very wide classes. To elucidate this point of view several examples are given. It is emphasized that the mysticism in regard to these types bears a faint similarity to the superstition of racism.

Résumé.

La conception de différents types corporels est une méthode primitive d'indiquer des corrélations entre des classes très étendues. Divers exemples qui sont donnés, illustrent ce point de vue. L'auteur insiste sur le fait qu'une croyance mystique dans ces différentes types rappelle vaguement la superstition du racisme.

Zusammenfassung.

Der Begriff „verschiedene Körpertypen" wurde besprochen und als eine primitive Methode befunden um Korrelationen zu zeigen unter Benutzung sehr weiter Klassen. Um diesen Gesichtspunkt zu erklären wurden verschiedene Beispiele gegeben. Es wird besonders betont, daß der Mystizismus im Hinblick auf diese Typen dem Aberglaube an die Rasse ein bißchen ähnlich ist.

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THE FREQUENCY OF ORTHOSTATIC ANAEMIA AT DIFFERENT AGES

by GUNNAR DAHLBERG

In all peoples there are found relatively tall and thin individuals. These types have been given various names. The most common term is that of asthenic body-build. It has been a common endeavour to prove a connection between this type of bodybuild and other qualities. The most well-known study was carried out by *Kretschmer.* He maintained, as is well known, that asthenics or, as he termed them, leptosomatics are of a certain psychic type which more or less resembles the schizophrenic. This connection between psychic qualities and body-build, which he assumed to exist, is, however, an object of much discussion. It being true that people generally increase in weight with age, the asthenic types are consequently more common among young people. Among young insane people, schizophrenics are more common than manic-depressives. The significance of age in relation to the asthenic body-build appears from, among others, an investigation by *C. R. Garvey*. This author failed to establish any difference in the frequency of asthenic constitution when comparing the schizophrenics and the manic-depressives at the same age. Body-build depends also to a certain extent on nutrition and thereby on appetite. Among the schizophrenics nutrition is often very bad, and sometimes refusal to eat occurs, making tube-feeding necessary.

Among the asthenic types there has been observed a certain tendency to that form of circulation disorder which is called orthostatic anaemia. It was *Laurell* and *Bjure* (1927) who first investigated this phenomenon. In their work, figures from 7 cases are given in order to illustrate the mechanism. The pulse difference in these varied from 11 to 36 pulsations per minute between standing and lying position, and was on an average 22 pulsations. Experiments were made on 3 of these individuals. The patient was placed in water up to the mammillary plane, following which the pulse decreased to approximately the same value as in the lying position. Their theory can briefly be characterized in the following manner:

Schematically, the essential point in orthostatic anaemia is that the abdomen is long and thin and not filled by abdominal organs. Therefore, these sink down to the lower part of the abdomen, so that in standing position the diaphragm is low. Because of this, the diaphragm cannot in breathing have so much movement. Consequently, when breathing, the intermittent pressure on the abdominal organs becomes slight. The blood is thus not pumped up to the heart as in other individuals. The heart then seeks to compensate for the decreased blood supply by a more rapid pulse rate, and therefore the pulse increases in standing position. In spite of this the minute volume of the heart remains small, and the brain receives little blood. This condition causes a variety of disorders. In animals where the heart has not become attached to the diaphragm, e. g., the rabbit, the erect position, as when the animals are kept hanging by their ears, causes death within a few minutes. Asthenic people are likely to faint, and they suffer from so-called neurasthenic disorders such as headaches, general discomfort, etc. This disorder of the circulation occurs especially in individuals with slack abdominal muscles, e. g., in pregnant women. *Laurell* distinguishes between constitutional and acquired tendencies to orthostatic anaemia.

Later, *Laurell* (1936) gave a fuller description of those symptoms associated with orthostatic arterial anaemia, and pointed out that the symptoms disappear at higher ages when the weight increases, and that the mental and bodily efficiency of the patient then also increases. The principal symptoms are those arising from the nervous

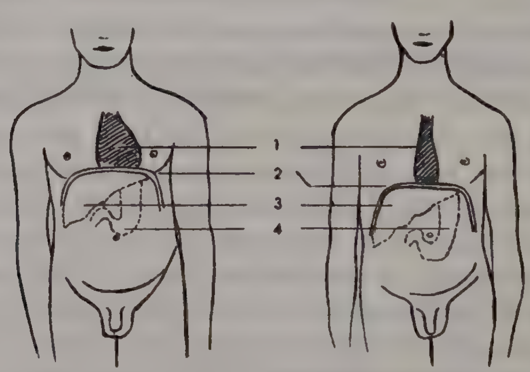

Fig. 1. Orthostatic anaemia in asthenic body-build. To the left: Normal body-build. To the right: Asthenic body-build. 1. The heart. 2. The diaphragm. 3. The liver. 4. The stomach. Observe the low position of the organs in the figure to the right.

system and consist of abnormal fatiguability, need of sleep, slow mental response, depression, hypocondric ideas, etc. The patient can in some cases have pains arising from the muscles and called rheumatism. Naturally, they can also have orthostatic albuminuria.

Laurell has in another work (1937) pointed out that orthostatic anaemia should be of significance to the localization of tubercular lesions in the lungs. In other words, *Laurell* ascribes a very great, maybe too great, significance to this circulatory disorder.

Grill (1937) maintained that the essential point in orthostatic anaemia is too small a blood mass, enabling displacements to occur between the upper and lower halves of the body. It is of course a matter of opinion whether one says that the blood mass is too small, or that the blood vessels are too large.

It seems, however, that no investigation as to the tendency to orthostatic anaemia in the different age groups of the population exists. In view of this, we have made an examination of the individuals at different ages in order to establish the occurrence of pulse differences between the standing and lying position.

We have examined school children at Uppsala, 1.597 boys and 1.526 girls aged between 7 and 19 years. We have further examined 684 conscripted men aged 20 years, and 329 aged 21 years. The material comprised in all 4.136 individuals. At the time of the examination they had to lie down for 5 minutes; their pulse was then taken, and they then stood for 2 minutes before the pulse was retaken. It was counted for ½ minute by stop-watch. In the following account, figures for one minute are given, being obtained by doubling the measurements. This was done because pulse rate is usually stated per minute, and such figures are therefore more readily understood. By comparing the right and left arms of the same person for a number of individuals, a methodical error of 1½ pulsations per ½ minute was obtained, which shows that the measurements were taken with satisfactory accuracy. When examining a smaller number of individuals, it was evident that a longer time did not affect the pulse rate for the majority of the individuals; this does not of course exclude the possibility that the effect in the same individuals, particularly those of the so-called asthenic type, is considerably more pronounced after they have taken up the respective position for some time.

The results of the examination appear in table 1. It is first to be seen that the pulse rate decreases according to age, from about

Table 1.

Pulsations per minute after 2 minutes in standing position and after 5 minutes in lying position in boys and girls of different ages.

Age, completed years	Boys					Girls				
	Number	After 2 minutes in standing position		After 5 minutes in lying position		Number	After 2 minutes in standing position		After 5 minutes in lying position	
		$M \pm \varepsilon$ (M)	σ (M)	$M \pm \varepsilon$ (M)	σ (M)		$M \pm \varepsilon$ (M)	σ (M)	$M \pm \varepsilon$ (M)	σ (M)
School children										
7	78	102.5 ± 1.1	9.4	99.2 ± 1.2	10.3	107	102.1 ± 1.0	10.6	99.9 ± 1.0	10.1
8	114	100.9 ± 0.8	8.7	98.8 ± 0.9	9.6	110	$100 8 \pm 0 9$	9.4	98.3 ± 0.9	9.7
9	137	98.4 ± 0.8	9.5	97.0 ± 0.8	9.7	116	99.0 ± 0.9	9.2	97.4 ± 0.9	9.9
10	131	94.6 ± 0.9	9.8	92.1 ± 1.0	11.4	135	96.5 ± 0.8	9.1	93.3 ± 0.9	10.1
11	152	94.7 ± 0.8	10.3	91.4 ± 0.9	10.9	165	96.8 ± 0.7	9.1	93.9 ± 0.9	11.5
12	172	94.6 ± 0.7	8.9	91.2 ± 0.8	10.6	196	96.4 ± 0.7	9.8	91.3 ± 0.8	11.3
13	181	94.2 ± 0.8	10.2	90.6 ± 0.8	10.8	164	94.0 ± 0.9	11.5	90.9 ± 0.9	11.1
14	145	92.4 ± 0.9	10.3	88.5 ± 0.9	10.4	111	90.3 ± 1.1	11.3	87.5 ± 1.1	11.2
15	125	90.0 ± 1.1	12.7	84.4 ± 1.1	12.4	68	91.4 ± 1.4	11.7	88.0 ± 1.7	14.3
16	110	87.2 ± 1.0	10.0	82.7 ± 1.2	12.1	116	89.5 ± 1.1	11.3	85.2 ± 1.1	11.4
17	101	85.7 ± 1.2	11 7	80.3 ± 1.1	10.9	111	90.6 ± 1.1	11.9	87.1 ± 1.2	12.6
18	93	85.4 ± 1.1	10.7	81.4 ± 1.1	10.8	79	85.7 ± 1.2	10.8	81.0 ± 1.2	10.5
19	58	85.4 ± 1.5	11.2	79.3 ± 1.5	11.7	48	85.5 ± 1.4	9.9	79.8 ± 1.6	10.8
Conscripts										
20	684	83.2 ± 0.4	10.7	72.1 ± 0.4	10.7					
21	329	81.3 ± 0.6	10.4	71.1 ± 0.6	10.2					

100 in a lying position at 7 years of age to about 80 in a lying position at 19 years of age, i. e. on an average by approximately 2 pulsations per year. No difference seems to occur between boys and girls. That the pulse changes according to age has been shown previously by *Volkmann* (1850). His figures correspond rather well with ours, though they are insignificantly lower. The advantage of our data is probably that we are able to give the variation range.

The important fact arising from our examination is however the difference which is found between the pulse rates in lying and standing positions. In order better to illustrate these conditions, we give the figures for the obtained differences in table 2. It appears from this table that the difference is comparatively small for the younger ages. After approximately 10 years of age, it begins to increase and

Table 2.

Individual differences between the number of pulsations per minute after 2 minutes in standing position and the number after 5 minutes in lying position, in boys and girls of different ages.

Age, completed years	Boys		Girls	
	Individual differences between number of pulsations after standing, respectively lying position.			
	$M \pm \varepsilon$ (M)	σ (M)	$M \pm \varepsilon$ (M)	σ (M)
School children:				
7	3.34 ± 1.00	8.84	2.28 ± 0.76	7.80
8	2.12 ± 0.72	7.76	2.42 ± 0.64	7.18
9	1.44 ± 0.70	8.30	1.58 ± 0.76	8.16
10	2.46 ± 0.76	8.74	3.26 ± 0.62	7.24
11	3.30 ± 0.72	8.88	2.90 ± 0.70	8.98
12	3.36 ± 0.58	7.50	5.10 ± 0.62	8.62
13	3.60 ± 0.60	8.00	3.12 ± 0.64	8.10
14	3.98 ± 0.66	7.98	2.80 ± 0.78	8.28
15	5.60 ± 0.66	7.32	3.44 ± 0.94	7.82
16	4.54 ± 0.68	7.24	4.30 ± 0.82	8.90
17	5.36 ± 0.70	7.12	3.58 ± 0.72	7.60
18	3.94 ± 0.74	7.18	4.72 ± 1.04	9.28
19	6.14 ± 1.32	10.12	5.70 ± 0.96	6.64
Conscripts:				
20	11.04 ± 0.32	8.28		
21	10.26 ± 0.44	8.02		

reaches its maximum value in males at 20–21 years of age. Our female material does not include ages exceeding 19 years, but here also the difference is greatest in the last age group. As to the pulse difference between the lying and standing positions at higher ages, we have no material with which to ascertain these conditions.

The average difference in conscripted men amounts to 10–11 pulsations per minute. There is however rather a great variation in the pulse difference at all ages. The standard deviation amounts to approximately 8 pulsations per minute. Taking this into consideration, it is first of interest to examine the distribution of the pulse difference in order to assure that it is not a question of a skew distribution. It appears, however, that the distribution is rather normal, which implies that several individuals show a negative difference, i. e., a lower pulse when standing than when lying. The situation is clarified by the diagram of pulse differences in conscripted men, i. e. men at 20–21 years of age (fig. 2).

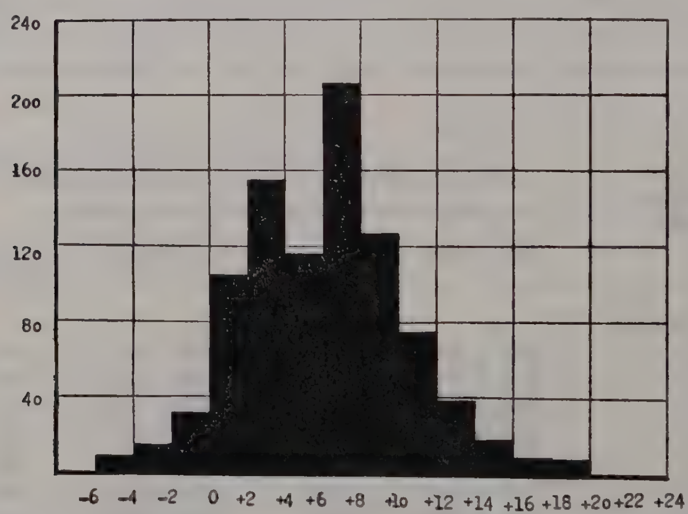

Fig. 2. Distribution of differences in pulse rate between standing and lying positions in conscripts.

Now it is the persons having a particularly great pulse difference between standing and lying positions who are of interest, for it is these who can be expected to suffer from orthostatic anaemia. The percentage of individuals with a pulse difference over 20 appears from table 3. The figures for the number of extreme

Table 3.

Percentual number of individuals of different ages having a difference of 20 pulsations or over per minute between standing and lying positions.

Age, completed years	Boys			Girls		
	Number of cases	Number with a pulse diff. of 20 or over		Number of cases	Number with a pulse diff. of 20 or over	
		Number	%		Number	%
School children:						
7	78	4	5.1	107	0	0
8	114	4	3.5	110	3	2.7
9	137	4	2.9	116	4	3.4
10	131	4	3.1	135	4	3.0
11	152	8	5.3	165	8	4.8
12	172	3	1.7	196	17	8.7
13	181	4	2.2	164	5	3.0
14	145	4	2.8	111	3	2.7
15	125	7	5.6	68	0	0
16	110	1	0.9	116	7	6.0
17	101	5	5.0	111	3	2.7
18	93	1	1.1	79	6	7.6
19	58	6	10.3	48	1	2.1
Conscripts:						
20	684	104	15.2			
21	329	43	13.1			

cases are of course very varying, but on the whole they give the impression that the percentages increase according to age and that they are highest in any case for boys and girls belonging to the older age groups i. e. in conscripted men at 20–21 years of age where it amounts to about 14 per cent and in the girls in the age groups immediately before 19 years of age. It is to be supposed that these individuals who show such a great difference in the pulse rate between lying and standing positions have disturbances due to this, but we have not made any special examination as to whether actual disturbances do occur. It appears from the table that extreme pulse differences are more common in boys than in girls in younger ages, and that the contrary is the case in subsequent ages up to 19 years

of age. The differences are however not significant and may therefore be due to random variation.

It now remains if possible to ascertain what can cause the pulse difference. We have first made a table to show to what extent a pulse difference occurs in individuals who have a different pulse rate when lying than when standing. It appears (table 4) that those with a low pulse rate when lying have on an average the greatest difference. The figures for the different age groups show throughout a displacement of this kind. The situation can be described as one in which those who have a low pulse when lying down have more latitude for manifesting a higher pulse rate when upright than those who have already a high pulse when prone. This is not entirely selfevident which is why the result can be said to be of some interest.

We have also information as to the weight and height of the conscripted men. It is therefore of interest to see whether a comparison of these qualities can give any results of interest. It must be borne in mind that orthostatic anaemia should occur most often in individuals who have an asthenic body constitution, i. e., in those who are comparatively tall and thin. If their weight is considered (table 5). it is found that those who have a great pulse difference between standing and lying positions, i. e., one exceeding 20 beats per minute, have on an average a higher weight than those who do not have such a great difference, or have a negative one. As regards height, it appears that those with a great pulse difference are also taller than the others. Then it is true that individuals who are both taller and weigh more, i. e. are bigger, have a greater pulse difference than those who are small. The question now arises: is it height or weight which has the strongest connection with the pulse difference. To determine this we have calculated *Rohrer*'s index (I) and made a comparison between this index and the pulse difference. *Rohrer*'s index is calculated according to the formula:

$$I = \frac{100\ P}{L^3}$$

where P is the weight in grams and L the height in centimeters. Hence, it expresses an individual's weight in proportion to height so that persons who are comparatively thin have a lower index than those who are comparatively stout and of equal height. It then appears that those who have a great pulse difference (exceeding 20

Pulse differences between standing and lying positions in individuals of different ages who differ in pulse rate after 5 minutes in lying position.

Number of pulsations per min. after 5 min. in lying position	Age at the examination; completed years											
	At most 10 years of age			11–15 years of age			16 years of age and over			All the age groups		
	Number	$M \pm \varepsilon(M)$	$\sigma(M)$	Number	$M \pm \varepsilon(M)$	$\sigma(M)$	Number	$M \pm \varepsilon(M)$	$\sigma(M)$	Number	$M \pm \varepsilon(M)$	$\sigma(M)$
School boys:												
60 – 69	5	22.00	–	23	10.70 ± 1.78	8.52	38	9.36 ± 0.85	5.24	66	10.78 ± 1.00	8.10
70 – 79	21	8.10 ± 1.52	7.00	99	8.98 ± 0.69	6.88	141	7.34 ± 0.54	6.34	261	8.02 ± 0.42	6.64
80 – 89	79	6.68 ± 0.92	8.14	250	6.08 ± 0.42	6.64	121	3.84 ± 0.62	6.84	450	5.58 ± 0.34	7.06
90 – 99	173	2.72 ± 0.54	7.16	233	2.00 ± 0.50	7.50	75	1.46 ± 0.96	8.26	481	2.18 ± 0.34	7.52
100 – 109	160	–0.22 ± 0.56	7.02	140	–0.12 ± 0.64	7.56	25	0 ± 1.54	7.72	325	–0.16 ± 0.40	7.30
110 – 119	36	–4.28 ± 1.20	7.22	21	–2.00 ± 1.78	8.20	4	–0.50	–	61	–3.24 ± 0.94	7.36
120 and more	13	–6.16	–	4	–9.00	–	–	–	–	17	–6.82 ± 1.28	5.30
All cases[1])	487	2.08 ± 0.38	8.34	775	3.94 ± 0.28	7.98	415	5.04 ± 0.38	7.58	1677	3.68 ± 0.20	8.06
School girls:												
60 – 69	2	14.00	–	13	14.46	–	33	9.10 ± 1.00	5.72	48	10.76 ± 1.06	7.34
70 – 79	22	12.46 ± 1.66	7.78	98	8.84 ± 0.84	8.28	95	6.70 ± 0.74	7.27	215	8.26 ± 0.54	7.98
80 – 89	79	5.54 ± 0.86	7.56	201	6.18 ± 0.54	7.70	128	5.10 ± 0.70	8.00	408	5.72 ± 0.38	7.78
90 – 99	177	2.62 ± 0.48	6.44	209	1.92 ± 0.52	7.50	77	1.50 ± 0.76	6.60	463	2.12 ± 0.32	6.98
100 – 109	184	0.52 ± 0.50	6.70	145	–0.44 ± 0.56	6.68	36	–2.62 ± 1.54	9.22	365	–0.18 ± 0.36	7.02
110 – 119	38	–3.22 ± 1.02	6.24	24	–1.66 ± 1.48	7.26	7	–2.00	–	69	–2.56 ± 0.85	7.06
120 and more	9	–4.88	–	12	–4.50	–	1	0	–	22	–4.46 ± 1.88	8.84
All cases	511	2.22 ± 0.34	7.56	704	3.64 ± 0.32	8.44	379	4.32 ± 0.42	8.24	1594	3.34 ± 0.20	8.16
Conscripts:												
20 years of age and over												
50 – 59	100	15.64 ± 0.79	7.94									
60 – 69	309	13.12 ± 0.47	8.22									
70 – 79	383	10.16 ± 0.36	6.88									
80 – 89	195	7.78 ± 0.56	7.84									
90 – 99	41	5.90 ± 0.88	5.66									
100 and more	17	–0.36 ± 2.62	10.80									
All cases	1056	10.82 ± 0.26	8.20									

[1]) In "all cases" a few individuals are included who fall outside the groups in the columns. Therefore the figure for "all cases" does not always agree with the sum of the cases in the columns.

Table 5.

Mean (M), standard error of the mean (ε), and standard deviation σ for body weight (in kgs), height (in cm), and *Rohrer*'s index among conscripts 20–21 years of age, distributed according to pulse difference between standing and lying positions.

Pulse diff. between standing and lying positions	Age of the conscripts								
	20 years old			21 years old			Total		
	Number	$M \pm \varepsilon$ (M)	σ	Number	$M \pm \varepsilon$ (M)	σ	Number	$M \pm \varepsilon$ (M)	σ
		Weight, kg:							
–1 and less	38	67.39 ± 1.17	7.19	19	64.03 ± 1.68	7.34	57	66.27 ± 0.96	7.28
0 – 19	542	68.41 ± 0.28	6.55	267	68.70 ± 0.43	7.09	809	68.50 ± 0.24	6.74
20 and more	104	69.73 ± 0.74	7.53	43	69.94 ± 1.06	6.98	147	69.79 ± 0.61	7.35
Total	684	68.55 ± 0.26	6.76	329	68.59 ± 0.40	7.17	1013	68.56 ± 0.22	6.90
		Height, cm:							
–1 and less	38	173.03 ± 1.04	6.40	19	170.32 ± 1.86	8.11	57	172.12 ± 0.93	7.00
0 – 19	542	174.43 ± 0.25	5.90	267	174.28 ± 0.38	6.16	809	174.38 ± 0.21	5.99
20 and more	104	176.65 ± 0.68	6.99	43	176.88 ± 0.88	5.78	147	176.72 ± 0.55	6.66
Total	684	174.69 ± 0.24	6.17	329	174.40 ± 0.35	6.37	1013	174.60 ± 0.20	6.23
		Rohrer's index:							
–1 and less	38	1.30 ± 0.019	0.12	19	1.28 ± 0.033	0.14	57	1.29 ± 0.016	0.12
0 – 19	542	1.29 ± 0.005	0.11	267	1.29 ± 0.007	0.11	809	1.29 ± 0.004	0.11
20 and more	104	1.26 ± 0.010	0.10	43	1.26 ± 0.015	0.10	147	1.26 ± 0.008	0.10
Total	684	1.28 ± 0.004	0.11	329	1.29 ± 0.006	0.11	1013	1.29 ± 0.003	0.11

pulsations per minute) do have a somewhat lower index than those who have a small difference. This difference is not great, but it is statistically significant, i. e., more than three times its standard error. In short, our investigation shows that the frequency of individuals who have a pulse difference between lying and standing positions increases up to 20 years of age. It is not greatest at puberty as one might be tempted to believe. Furthermore, it has been possible to prove that pulse differences of this kind are associated with a tall and thin body-build characterized by a comparatively low *Rohrer*'s index. It would be of interest to investigate to what extent individuals with a great pulse difference have difficulties due to this. The circumstances did not allow an extension of the investigation on this point. We must limit ourselves to pointing out that naturally it cannot be expected that all people with a certain pulse difference between standing and lying positions will have difficulties. Tolerance is without doubt also different in different individuals. It must be borne in mind that disturbances of the same kind occur also in people who do not have an asthenic body constitution; for instance, women who have been pregnant and consequently have slack abdominal muscles can also develop severe disorders when standing. Similarly, there exist people who have lost weight. It must be brought to mind that some of those fainting attacks occurring in crowds of people for example at Princess Elisabeth's wedding ought to be conditioned by orthostatic anaemia.

Formerly there was reason to believe (at least I believed it myself) that orthostatic anaemia was especially frequent in boys at puberty. Even if that is not so, the anomaly is of especial importance among school children, mainly because of the difficulty for such children to work effectively in the morning hours. Especially if they have not got any substantial food before going to school and if they have not had any opportunity of moving about, they will not feel up to the mark. After lunch they will feel better but during the last lessons of the day they will again be a little slow and dull. When coming home they won't have very good appetite. If they then are allowed to lie down for a quarter of an hour, they will feel all right. They will not be very good at tests in school lasting for several hours. Their condition requires especial regard from the teacher. It is a pity that the mechanism of this anomaly is not more generally known among teachers and parents. Even among medical men the condition is hardly as well-known as it ought to be.

Summary.

Orthostatic anaemia is diagnosed by the help of a great difference in pulse rate when standing and lying down. This symptom is especially common among individuals of asthenic body-build, but may also occur in other persons. The frequency of individuals with especially great differences in pulse rate is investigated. The symptom appears to be no more common in boys than in girls but more common at 21 years of age than in younger persons.

Résumé.

Le diagnostic de l'anémie orthostatique est basé sur une différence importante dans le taux des pulsations en position debout ou couchée. Ce symptôme est particulièrement fréquent chez les individus de type asthénique mais existe aussi parfois chez d'autres. Des recherches furent faites sur la fréquence de ce symptôme. Il semble être plus fréquent chez les garçons que chez les filles et plus fréquent à l'âge de 21 ans qu'au-dessous de cet âge.

Zusammenfassung.

Die orthostatische Anämie wird durch die große Differenz der Pulshastigkeit im Stehen und Liegen diagnostiziert. Dieses Symptom ist besonders häufig bei Menschen mit asthenischem Körperbau, kann aber auch bei anderen Typen vorkommen. Die Häufigkeit von Personen mit besonders großen Differenzen der Pulshastigkeit wurde untersucht. Das Symptom scheint bei Knaben nicht öfter als bei Mädchen vorzukommen; ist jedoch häufiger bei 21jährigen als bei jüngeren Personen.

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SUICIDE, ALCOHOL AND WAR

by GUNNAR DAHLBERG

The French sociologist *Durkheim* put forward a theory which attracted very great attention at the time and which dealt, among other things, with suicide. In a society where the conventional morals are strict, people are envious of those who satisfy their wishes and desires by overstepping moral barriers. He calls this *mal d'infini*, or the sickness of infinite possibilities. Life is exciting and adventurous simply because morals are strict. It is fun to be alive because there are so many rules to be broken. Forbidden joys are specially tempting. *Durkheim* starts out from a nihilistic standpoint and ends up with a strict and conventional morality.

He used, among other things, the statistics for suicide, in trying to prove his theory. He maintained that suicide diminishes in wartime. He considered that this was because the bonds uniting all members of the community were drawn taut, so that life became exciting. Life acquires an enhanced interest in other respects too; it is fun to read the newspapers.

The available statistics concerning the frequency of suicide are very imperfect. People try to conceal suicide and, to a greater or lesser extent, some other cause of death is given. This was even more the case previously than it is now. In different countries and at different periods the ethical ideas on suicide have been of a different nature. The ancient Greeks and Romans considered suicide as perfectly natural behaviour. Some peoples have considered that honour demanded suicide of persons who, for one reason or another, found themselves in an ignominious position. There is no pronouncement against suicide either in the Old or New Testament. Following *St. Augustine*, the Catholic Church considered suicide as a sin. The suicide was denied burial in consecrated ground, and, owing to the

temporal influence of the church, other penalties were also imposed. The property of the suicide was confiscated. People have become more tolerant in recent years, partly because it has been shown that suicide not infrequently arises out of mental disorder. Owing to the Christian tradition, however, there is still a tendency to regard suicide as shameful and to conceal it if possible. One cannot therefore consider the statistics for the frequency of suicide as reliable, nor can one compare statistical information from different countries as *Durkheim* does in his book *Le suicide* (1930). The frequency of suicide has, on the whole, been on the increase during recent years. This is partly to be associated with an improvement of registration, and partly with the fact that the Christian religion is losing its hold over people's minds. Under such circumstances it is only permissible to compare the figures over relatively short periods and for the same country. If registration is carried out in the same way one may then reckon that the proportion of cases which failed to get included in the statistics was the same in the periods being compared. This,

Table 1.

Annual number of suicides per million of the population over 10 years of age in Sweden during the period 1911–1944. Men and women.

Year	Men	Women	Year	Men	Women
1911	375.0	81.6	1928	284.3	58.5
1912	392.9	80.5	1929	305.6	70.0
1913	382.5	81.1	1930	307.6	73.2
1914	336.3	73.9	1931	314.7	79.3
1915	315.6	79.7	1932	352.4	68.6
1916	264.7	72.5	1933	326.6	78.1
1917	197.9	60.0	1934	295.2	64.7
1918	191.2	91.7	1935	289.6	73.4
1919	272.1	69.3	1936	309.3	80.0
1920	294.2	75.1	1937	278.7	83.7
1921	307.2	76.5	1938	289.1	78.3
1922	290.6	69.0	1939	295.3	79.8
1923	289.3	64.5	1940	315.0	81.6
1924	293.1	66.7	1941	286.7	80.4
1925	267.0	67.1	1942	253.8	80.1
1926	301.2	63.1	1943	260.6	93.2
1927	299.9	71.6	1944	242.2	66.0

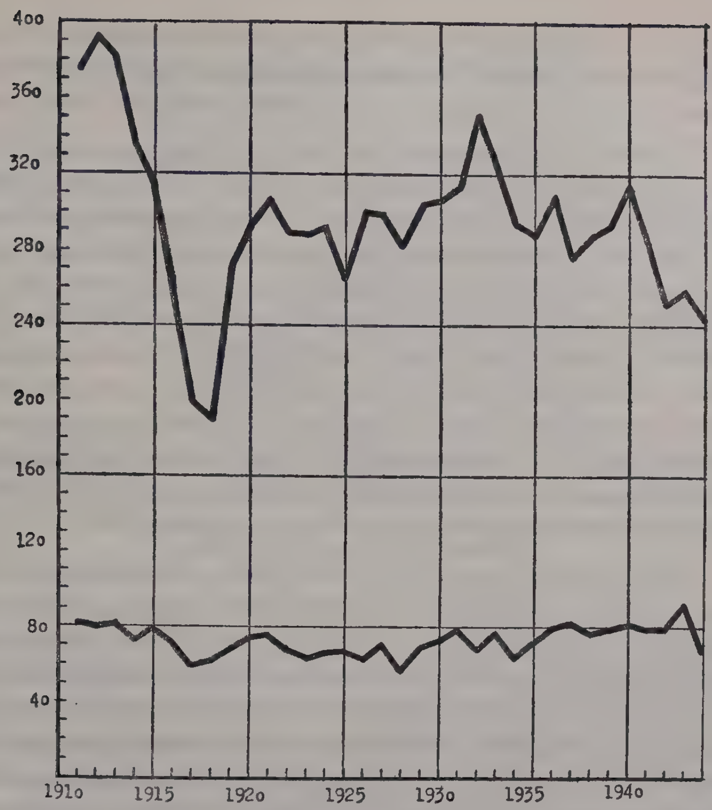

Fig. 1. Annual number of suicides per million of the population (over 10 years of age) in Sweden during the period 1911–1944. Upper curve: men; lower curve: women.

however, is not the case for belligerent countries. When soldiers commit suicide people prefer not to register it as suicide out of concern for the maintenance of morale. Some cases of suicide look like "death from natural causes" – the person concerned has died the death of a hero for his country. This may well be the cause of the lower frequency of suicide during wartime which was observed by *Durkheim* and others.

It is of special interest from the point of view of *Durkheim*'s theory, to compare the figures for Sweden from the two World Wars. We were neutral, but even so we had quite an anxious time. Even here measures were taken to "strengthen morale" in wartime, especially during the Second World War. If *Durkheim*'s theory were

correct one would expect to find a fall in the frequency of suicide during both the World Wars, and furthermore, the frequency ought to have fallen more during the last war than during the previous one.

A review of the frequency of suicide during the period 1911–1944 inclusive is given in Table 1 and Figure 1. It may be observed that the frequency of suicide among women has remained practically constant in recent years. On the other hand, there was a great decrease in the frequency of suicide among men during the First World War, which was most marked in the years 1917–18. It diminished by almost half. After the end of the war the frequency quickly rose again to its "normal level" where it remained fairly constant. (The curve shows a peak in 1932 which may perhaps be associated with the economic crisis). However there was no change in the frequency of suicide for the first 4½ years (1939–1944) of the last war for which the figures are now published.

The Swedish figures thus do not confirm *Durkheim*'s theory. The remarkable fall during the First World War must have had some cause which only affected men and not women. Furthermore the factor concerned must have been one which was only in action during the First World War and not during the last one. I have already pointed out that the simplest explanation is that during the First World War "spirits were not so freely available as they were before and after the war", (*Dahlberg* 1937). It may be remembered that at that time it was found impossible to manufacture as much spirits as previously, owing to the potato shortage. The scarcity of spirits was so great that it led to the introduction of a rationing system which was so strict during the First World War that the allocation only amounted to 1 litre a quarter, during the later part of the war. The drinking of spirits leads to habitual drunkenness and is a direct cause of suicide. Effective rationing must therefore have its advantages. An important point is that unhappy or depressed people suffer from an impairment of their judgement or an increase in their depression either while still in their cups or afterwards and this leads to their committing suicide. The strict rationing of spirits explains the dissimilarity between men and women during the First World War.

I followed the figures for the last war with special interest having regard to the hypothesis I have put forward. Spirits were now manufactured from cellulose and the restrictions imposed

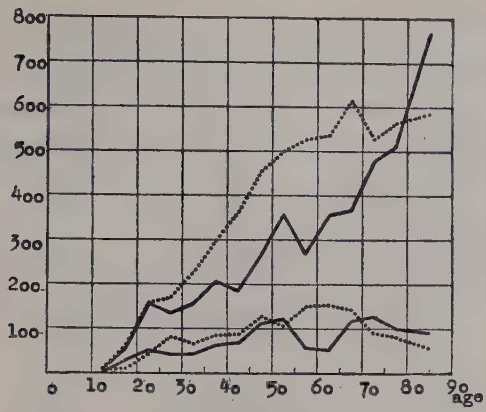

Fig. 2. Annual number of suicides per million men (the two upper curves), respectively women (the two lower curves) in different age groups. The whole lines give the frequency during the war years 1917–1918, the dotted lines the frequency during the war years 1940–1941.

were far milder than the corresponding measures during the previous war. The fact that the frequency of suicide did not diminish this time lends great support to my hypothesis.

Considering the frequency of suicide from the point of view of age we find that it is characteristic that among women the risk of suicide increases slowly from the age of 15–20 years until the age of 50 years, after which it remains fairly constant. The curve for men rises much more steeply and continues to rise to a later age. Fig. 2 shows the curves for men and women for the war years 1917–1918 and for those 1940–1941. The curves for the earlier years lie at a lower level from the ages 25–30 onwards. According to my hypothesis the simplest interpretation of the figures is that spirits have no appreciable significance in determining suicide among younger people, whereas among middle-aged and elderly people they play an important part. It may be pointed out, in order to give a concrete measurement of the importance of spirits in this respect, that if the same restrictions had been put on the consumption in this country during the last war as were imposed during the previous one, and if they had had the same effect as I believe they had during the First World War the number of cases of suicide would have been less by 400 a year.

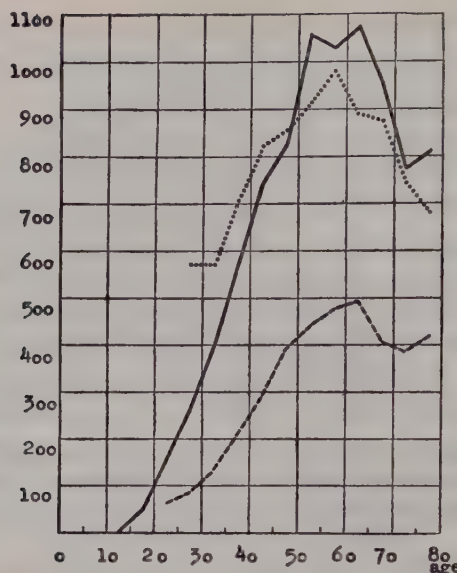

Fig. 3. Annual number of suicides per 1 million men of different civil status during the period 1921–1940. The whole line gives the frequency among unmarried men, the dotted line the frequency among widowers and divorced men, and the broken line the frequency among married men.

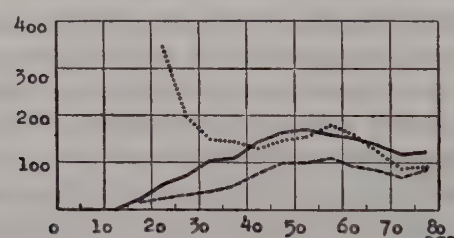

Fig. 4. Annual number of suicides per 1 million women of different civil status during the period 1921–1940. The whole line gives the frequency among unmarried women, the dotted line the frequency among widows and divorced women, and the broken line the frequency among married women.

Finally, Figs. 3 and 4 show curves for the frequency of suicide among men and women of different civil status.

The first point to be noted is that the frequency of suicide is lower among the married than among the unmarried. This holds for both men and women and for all age-groups. It appears also to be

the case that the frequency of suicide among widowed and divorced people is even greater than among unmarried persons in the younger age-groups, though it is somewhat less in the older age-groups. The official statistical figures do not allow of drawing any distinction between widowed and divorced persons. The available figures appear to indicate that, for younger people (under 30–35 years), the dissolution of marriage by death or divorce may be a very serious matter and lead to suicide. This is especially the case among women. As people get older they take the matter more calmly. The dangerous age for women is before 35–40 years.

Summary.

The frequency of suicide decreased in Sweden during the first World War, though only in regard to men. The author tries to show that the decrease was connected with the consumption of spirits. During the first World War the supply of spirits was very scanty in Sweden. During the second World War there were no special restrictions, nor decreased the frequency of suicide among men. Suicides in connection with consumption of spirits is elucidated in several respects.

Résumé.

La fréquence des suicides diminua en ce qui concerne les hommes au cours de la première guerre mondiale. L'auteur s'efforce de montrer que cette constatation est en relation avec la consommation d'alcool. Au cours de la première guerre mondiale, l'alcool était très rare. Au cours de la deuxième, en revanche, il n'y eut pas de restrictions spéciales: la fréquence des suicides chez les hommes ne diminua pas.

Considérations diverses sur la relation des suicides et l'alcool.

Zusammenfassung.

Die Selbstmordfrequenz nahm in Schweden während des ersten Weltkrieges ab, doch gilt dies nur für Männer. Der Verfasser versucht zu zeigen, daß dies mit dem Alkoholgenuß zusammenhängt. Während des ersten Weltkrieges war das Angebot an Alkohol in Schweden sehr knapp. Während des zweiten Weltkrieges gab es keine besonderen Restriktionen. Die Selbstmordfrequenz bei Männern fiel auch

nicht. Selbstmord im Zusammenhang mit Alkohol wird in verschiedener Hinsicht beleuchtet.

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